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# FlyingFrames

**kolibril13**

**Dec 10, 2022**



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Hi! FlyingFrames is a project by me (kolibril13), where I want to provide you some tutorials and code snippets that I often use when I prepare my animations for my youtube channel: <https://www.youtube.com/c/kolibril> It does not replace the amazing documentation at <https://docs.manim.community/en/stable/> , but I hope this blog will give you some inspiration for your future projects.



## CONTENT

## 1.1 Manim in Jupyter

Working with manim in jupyter notebooks has several advantages:

- code snippets and rendered outputs are close together
- easy to iterate examples
- easy to try different varieties of one scene in multiple cells
- computation intensive code can be executed separately from the scenes
- global Mobjects can be used in multiple scenes.

### 1.1.1 Simple Example

First, we need to import manim

```
[1]: from manim import *  
    config.media_embed = True  
  
Manim Community v0.17.1
```

Now we build up our scene

```
[2]: %%manim -v WARNING --progress_bar None -s -ql --disable_caching MyExample  
    class MyExample(Scene):  
        def construct(self):  
            m= ManimBanner()  
            self.add(m)
```



Note, that I use the following parameters:

- `-v WARNING` means that only warnings are shown in the log
- `--progress_bar None` will not show the animation progress bar
- `-s` will only show the last frame
- `-ql` renders in low quality
- `--disable_caching` will disable the manim caching system
- `MyExample` gives the scene name

for rendering a video, just remove the `-s` flag. To lower the resolution, you can use `-r 400,200` (pixel values in x and y direction).

```
[3]: %%manim -v WARNING --progress_bar None -r 400,200 --disable_caching HelloManim
class HelloManim(Scene):
    def construct(self):
        self.camera.background_color = "#ece6e2"
        banner_large = ManimBanner(dark_theme=False).scale(0.7)
        self.play(banner_large.create())
        self.play(banner_large.expand())

<IPython.core.display.Video object>
```

Rendering with a transparent background can be done like this:

```
[4]: %%manim -v ERROR --progress_bar None -r 400,200 -t --disable_caching HelloManim
class HelloManim(Scene):
    def construct(self):
        self.camera.background_color = "#ece6e2"
```

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```

banner_large = ManimBanner(dark_theme=False).scale(1.5)
self.add(banner_large)

```

```

[12/10/22 05:08:29] WARNING Output format set as webm, this can be slower than other
↳ formats ]8;id=702500;file:///home/docs/checkouts/readthedocs.org/user_builds/
↳ flyingframes/envs/v0.17.1/lib/python3.8/site-packages/manim/_config/utils.py\utils.
↳ py]8;;\:]8;id=820478;file:///home/docs/checkouts/readthedocs.org/user_builds/
↳ flyingframes/envs/v0.17.1/lib/python3.8/site-packages/manim/_config/utils.py#992\992]8;
↳ ;\

```



We can define the parameters as a string `param` and call this string by the cell magic with `$param`

```

[5]: param = "-v WARNING -s -ql --disable_caching Example"
paramSMALL = "-v WARNING -r 400,200 -s --disable_caching Example"

```

```

[6]: %%manim $param
class Example(Scene):
    def construct(self):
        m= ManimBanner()
        self.add(m)

```



### 1.1.2 Initializing Objects Outside the Class

In some cases, it might be convenient to define mobjects outside the Scene class (e.g. for uncluttering or for speeding up the animation).

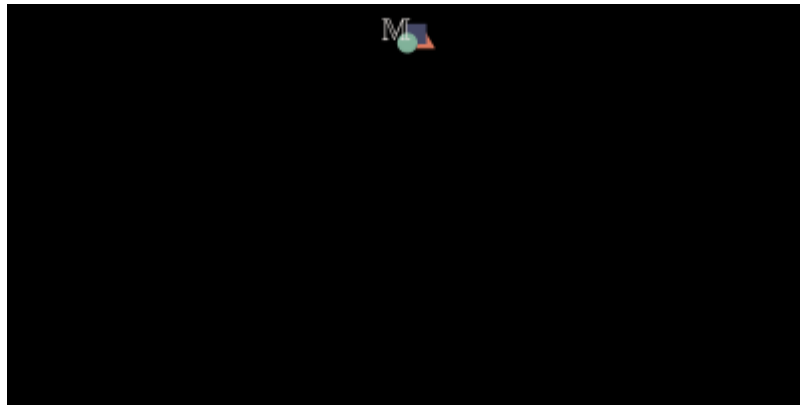
```
[7]: m = ManimBanner()
```

```
[8]: %%manim $paramSMALL
class Example(Scene):
    def construct(self):
        m.scale(0.4)
        m.shift(1.5*UP)
        self.add(m)
```



Because the mobject is manipulated in the class, the next cell might show some unexpected scaling and shifting:

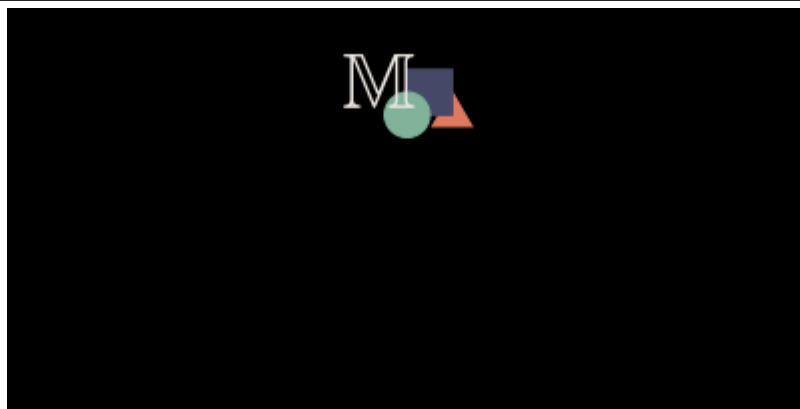
```
[9]: %%manim $paramSMALL
class Example(Scene):
    def construct(self):
        m.scale(0.4)
        m.shift(1.5*UP)
        self.add(m)
```



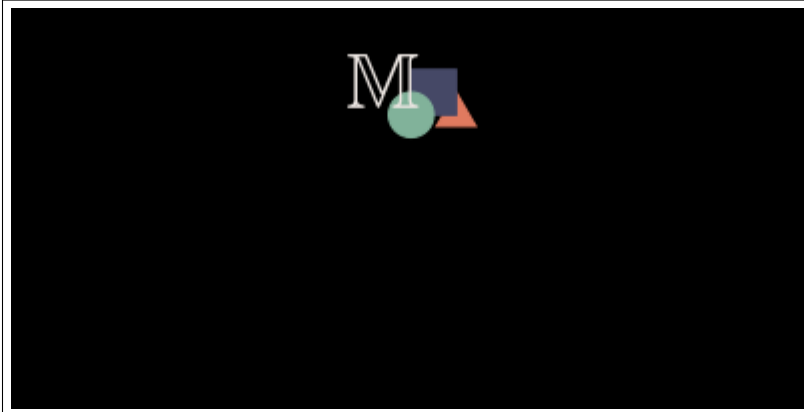
To avoid this, it is better to add only a copy of these mobjects to scenes, and keep the originals untouched:

```
[10]: m_reference = ManimBanner()
```

```
[11]: %%manim $paramSMALL
class Example(Scene):
    def construct(self):
        m = m_reference.copy()
        m.scale(0.4)
        m.shift(2*UP)
        self.add(m)
```



```
[12]: %%manim $paramSMALL
class Example(Scene):
    def construct(self):
        m = m_reference.copy()
        m.scale(0.4)
        m.shift(2*UP)
        self.add(m)
```



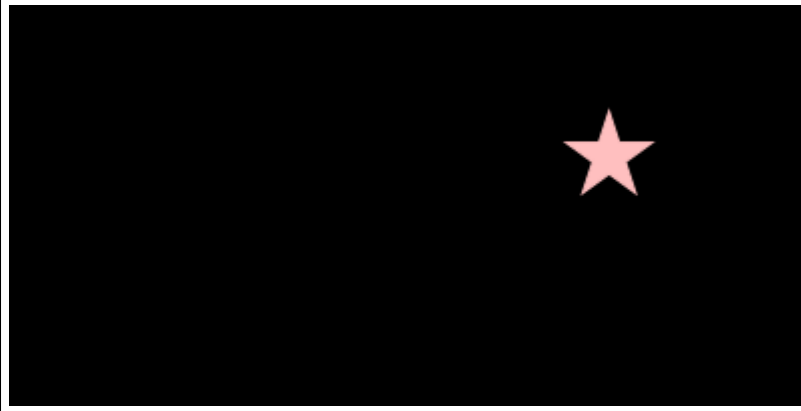
### 1.1.3 Defining Global Mobjects

When you have to build complex scenes, you might want to use parts of that scene for your next scene. That is possible with global variables, which can be accessed in any other scene.

```
[13]: %%manim $paramSMALL
class Example(Scene):
    def construct(self):
        stars= VGroup()
        for i in range(0,20):
            s= Star(color= random_bright_color(), fill_opacity=1).scale(0.8)
            stars.add(s)
        stars.arrange_in_grid()
        self.add(stars)
        global favoritstar
        favoritstar = stars[9]
```



```
[14]: %%manim $paramSMALL
class Example(Scene):
    def construct(self):
        self.add(favoritstar)
```



### 1.1.4 Pre-Execute Slow Code

In this example, calculating a random walk for 500 particles and 100000 steps takes about 4 seconds.

This step can be done before the actual scene construction, which takes about 0.2 seconds.

Making aesthetic changes to the scene will then become easier.

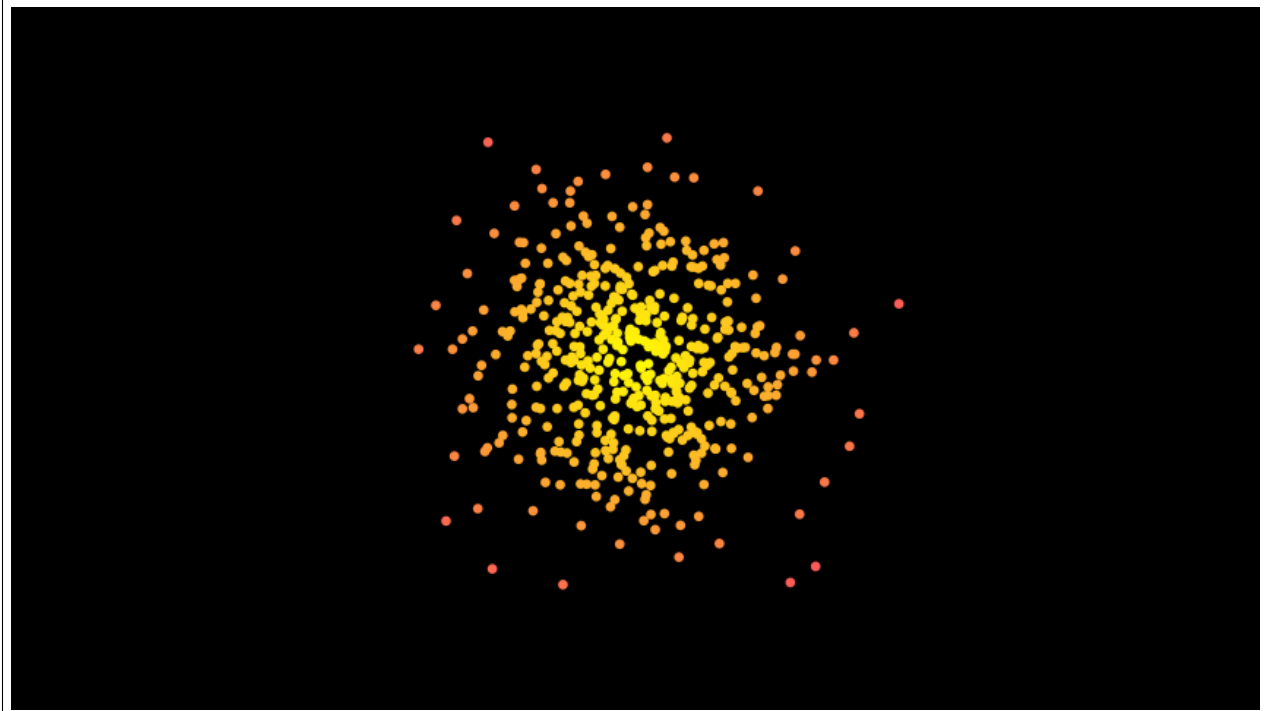
Note: The %%time command will print the execution time of the cells.

```
[15]: %%time
np.random.seed(20)
steps = np.random.choice(a=[-1, 0, 1], size=(100000,1000))
stop = steps.cumsum(0)
end_points= stop[-1]/stop[-1].max()
end_pointsX = end_points[0:499]
end_pointsY = end_points[500:-1]
```

CPU times: user 2.12 s, sys: 597 ms, total: 2.72 s

Wall time: 2.72 s

```
[16]: %%time
%%manim $param
class Example(Scene):
    def construct(self):
        radius= (end_pointsX*end_pointsX + end_pointsY * end_pointsY)**0.5
        dots = VGroup()
        for x,y,r in zip(end_pointsX, end_pointsY,radius):
            c= interpolate_color(YELLOW, RED, r)
            dots.add(Dot(color=c,point=[3*x,3*y,0]).scale(0.7))
        self.add(dots)
```



CPU times: user 462 ms, sys: 4.03 ms, total: 466 ms  
 Wall time: 467 ms

### 1.1.5 Installing Plugins

plugins can be found at <https://plugins.manim.community/>

[17]: !pip install manim-physics

```
Requirement already satisfied: manim-physics in /home/docs/checkouts/readthedocs.org/
  ↳ user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (0.2.4)
Requirement already satisfied: pymunk<7.0.0,>=6.0.0 in /home/docs/checkouts/readthedocs.
  ↳ org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from manim-
  ↳ physics) (6.4.0)
Requirement already satisfied: manim>=0.6.0 in /home/docs/checkouts/readthedocs.org/user_
  ↳ builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from manim-physics) (0.
  ↳ 17.1)
Requirement already satisfied: Shapely<2.0.0,>=1.8.0 in /home/docs/checkouts/readthedocs.
  ↳ org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from manim-
  ↳ physics) (1.8.5.post1)
Requirement already satisfied: isosurfaces==0.1.0 in /home/docs/checkouts/readthedocs.
  ↳ org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from manim>=0.6.
  ↳ 0->manim-physics) (0.1.0)
Requirement already satisfied: scipy<2.0.0,>=1.7.3 in /home/docs/checkouts/readthedocs.
  ↳ org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from manim>=0.6.
  ↳ 0->manim-physics) (1.9.3)
Requirement already satisfied: networkx<3.0,>=2.5 in /home/docs/checkouts/readthedocs.
  ↳ org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from manim>=0.6.
  ↳ 0->manim-physics) (2.8.8)
```

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```

Requirement already satisfied: requests<3.0.0,>=2.26.0 in /home/docs/checkouts/
↳readthedocs.org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages
↳(from manim>=0.6.0->manim-physics) (2.28.1)
Requirement already satisfied: Pygments<3.0.0,>=2.10.0 in /home/docs/checkouts/
↳readthedocs.org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages
↳(from manim>=0.6.0->manim-physics) (2.13.0)
Requirement already satisfied: srt<4.0.0,>=3.5.0 in /home/docs/checkouts/readthedocs.org/
↳user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from manim>=0.6.0->
↳manim-physics) (3.5.2)
Requirement already satisfied: tqdm<5.0.0,>=4.62.3 in /home/docs/checkouts/readthedocs.
↳org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from manim>=0.6.
↳0->manim-physics) (4.64.1)
Requirement already satisfied: screeninfo<0.9,>=0.8 in /home/docs/checkouts/readthedocs.
↳org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from manim>=0.6.
↳0->manim-physics) (0.8.1)
Requirement already satisfied: click-default-group<2.0.0,>=1.2.2 in /home/docs/checkouts/
↳readthedocs.org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages
↳(from manim>=0.6.0->manim-physics) (1.2.2)
Requirement already satisfied: numpy<2.0,>=1.19 in /home/docs/.pyenv/versions/3.8.6/lib/
↳python3.8/site-packages (from manim>=0.6.0->manim-physics) (1.19.2)
Requirement already satisfied: skia-pathops<0.8.0,>=0.7.0 in /home/docs/checkouts/
↳readthedocs.org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages
↳(from manim>=0.6.0->manim-physics) (0.7.4)
Requirement already satisfied: mapbox-earcut<2.0.0,>=1.0.0 in /home/docs/checkouts/
↳readthedocs.org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages
↳(from manim>=0.6.0->manim-physics) (1.0.1)
Requirement already satisfied: moderngl<6.0.0,>=5.6.3 in /home/docs/checkouts/
↳readthedocs.org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages
↳(from manim>=0.6.0->manim-physics) (5.7.3)
Requirement already satisfied: pydub<0.26.0,>=0.25.1 in /home/docs/checkouts/readthedocs.
↳org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from manim>=0.6.
↳0->manim-physics) (0.25.1)
Requirement already satisfied: pycairo<2.0,>=1.21 in /home/docs/checkouts/readthedocs.
↳org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from manim>=0.6.
↳0->manim-physics) (1.23.0)
Requirement already satisfied: Pillow<10.0,>=9.1 in /home/docs/checkouts/readthedocs.org/
↳user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from manim>=0.6.0->
↳manim-physics) (9.3.0)
Requirement already satisfied: watchdog<3.0.0,>=2.1.6 in /home/docs/checkouts/
↳readthedocs.org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages
↳(from manim>=0.6.0->manim-physics) (2.2.0)
Requirement already satisfied: rich!=12.0.0,>=6.0 in /home/docs/checkouts/readthedocs.
↳org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from manim>=0.6.
↳0->manim-physics) (12.6.0)
Requirement already satisfied: click<=9.0,>=7.2 in /home/docs/checkouts/readthedocs.org/
↳user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from manim>=0.6.0->
↳manim-physics) (8.1.3)
Requirement already satisfied: svgelements<2.0.0,>=1.8.0 in /home/docs/checkouts/
↳readthedocs.org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages
↳(from manim>=0.6.0->manim-physics) (1.8.4)
Requirement already satisfied: manimpango<0.5.0,>=0.4.0.post0 in /home/docs/checkouts/
↳readthedocs.org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages

```

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```

↳(from manim>=0.6.0->manim-physics) (0.4.3)
Requirement already satisfied: decorator<6.0.0,>=5.0.7 in /home/docs/checkouts/
↳readthedocs.org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages
↳(from manim>=0.6.0->manim-physics) (5.1.1)
Requirement already satisfied: cloup<0.14.0,>=0.13.0 in /home/docs/checkouts/readthedocs.
↳org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from manim>=0.6.
↳0->manim-physics) (0.13.1)
Requirement already satisfied: colour<0.2.0,>=0.1.5 in /home/docs/checkouts/readthedocs.
↳org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from manim>=0.6.
↳0->manim-physics) (0.1.5)
Requirement already satisfied: moderngl-window<3.0.0,>=2.3.0 in /home/docs/checkouts/
↳readthedocs.org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages
↳(from manim>=0.6.0->manim-physics) (2.4.2)
Requirement already satisfied: cffi>=1.15.0 in /home/docs/checkouts/readthedocs.org/user_
↳builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from pymunk<7.0.0,>=6.0.
↳0->manim-physics) (1.15.1)
Requirement already satisfied: pycparser in /home/docs/checkouts/readthedocs.org/user_
↳builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from cffi>=1.15.0->pymunk
↳<7.0.0,>=6.0.0->manim-physics) (2.21)
Requirement already satisfied: typing-extensions in /home/docs/checkouts/readthedocs.org/
↳user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from cloup<0.14.0,>
↳=0.13.0->manim>=0.6.0->manim-physics) (4.4.0)
Requirement already satisfied: glcontext<3,>=2.3.6 in /home/docs/checkouts/readthedocs.
↳org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from moderngl<6.
↳0.0,>=5.6.3->manim>=0.6.0->manim-physics) (2.3.7)
Requirement already satisfied: pyrr<1,>=0.10.3 in /home/docs/checkouts/readthedocs.org/
↳user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from moderngl-window
↳<3.0.0,>=2.3.0->manim>=0.6.0->manim-physics) (0.10.3)
Requirement already satisfied: pygame>=2.0dev23 in /home/docs/checkouts/readthedocs.org/
↳user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from moderngl-window
↳<3.0.0,>=2.3.0->manim>=0.6.0->manim-physics) (2.0.1)
Requirement already satisfied: idna<4,>=2.5 in /home/docs/checkouts/readthedocs.org/user_
↳builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from requests<3.0.0,>=2.
↳26.0->manim>=0.6.0->manim-physics) (3.4)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in /home/docs/checkouts/readthedocs.
↳org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from requests<3.
↳0.0,>=2.26.0->manim>=0.6.0->manim-physics) (1.26.13)
Requirement already satisfied: charset-normalizer<3,>=2 in /home/docs/checkouts/
↳readthedocs.org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages
↳(from requests<3.0.0,>=2.26.0->manim>=0.6.0->manim-physics) (2.1.1)
Requirement already satisfied: certifi>=2017.4.17 in /home/docs/checkouts/readthedocs.
↳org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from requests<3.
↳0.0,>=2.26.0->manim>=0.6.0->manim-physics) (2022.12.7)
Requirement already satisfied: commonmark<0.10.0,>=0.9.0 in /home/docs/checkouts/
↳readthedocs.org/user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages
↳(from rich!=12.0.0,>=6.0->manim>=0.6.0->manim-physics) (0.9.1)
Requirement already satisfied: multipledispatch in /home/docs/checkouts/readthedocs.org/
↳user_builds/flyingframes/envs/v0.17.1/lib/python3.8/site-packages (from pyrr<1,>=0.10.
↳3->moderngl-window<3.0.0,>=2.3.0->manim>=0.6.0->manim-physics) (0.6.0)
Requirement already satisfied: six in /home/docs/.pyenv/versions/3.8.6/lib/python3.8/
↳site-packages (from multipledispatch->pyrr<1,>=0.10.3->moderngl-window<3.0.0,>=2.3.0->
↳manim>=0.6.0->manim-physics) (1.15.0)

```



```
[18]: %%manim -v WARNING --progress_bar None -qm --disable_caching Example
```

```
from manim_physics import *

class Example(SpaceScene):
    def construct(self):
        circle = Dot(radius=1).shift(1.5*LEFT+3*UP)
        rect = Square(color=YELLOW, fill_opacity=1)
        ground = Line([-4, -3.5, 0], [4, -3.5, 0])
        wall1 = Line([-4, -3.5, 0], [-4, 3.5, 0])
        wall2 = Line([4, -3.5, 0], [4, 3.5, 0])
        walls = VGroup(ground, wall1, wall2)
        self.add(walls)
        self.add(rect, circle)
        self.make_rigid_body(rect, circle)
        self.make_static_body(walls)
        self.wait(5)
```

```
<IPython.core.display.Video object>
```

## 1.2 Mobject Gallery

Also available on this standalone website: <https://kolibril13.github.io/mobject-gallery/>

## 1.3 Mobject Basics

After reading this chapter, you will be able to build up Mobjects on scenes, no animations included yet. There will be lots of minimal examples and only very brief explanations.

```
[1]: from manim import *
config.media_embed = True
```

```
Manim Community v0.17.1
```

```
[2]: #ignore this cell, only for setup
param = "-v WARNING -r 500,100 -s --disable_caching Example"
parambigger = "-v WARNING -r 500,120 -s --disable_caching Example"
```

### 1.3.1 Positioning

First we want to position mobjects. There are tons of options, and not everything will be covered here.

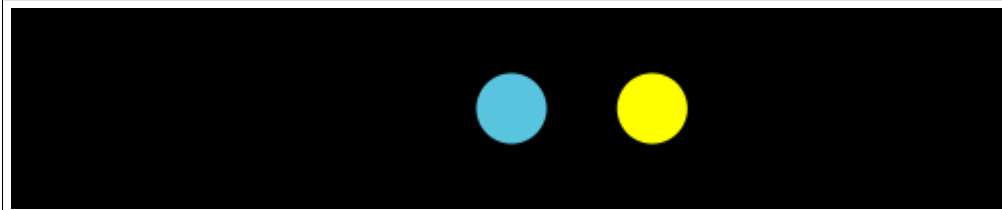
#### set positions

Some important methods to set positions are:

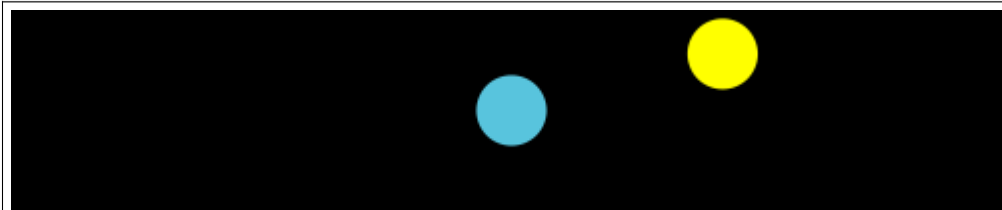
`shift` `move_to` `align_to` `next_to` `to_corner` `to_edge` `arrange` `arrange_in_grid`

```
[3]: dORIGIN= Dot(color= BLUE, radius=0.5)
```

```
[4]: %%manim $param
class Example(Scene):
    def construct(self):
        d= Dot(color= YELLOW, radius=0.5)
        d.shift(2*RIGHT)
        self.add(dORIGIN, d)
```



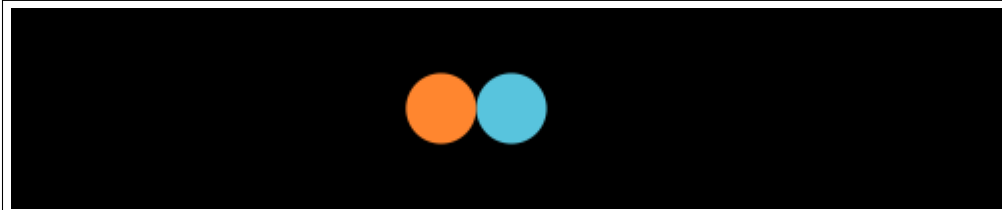
```
[5]: %%manim $param
class Example(Scene):
    def construct(self):
        d= Dot(color= YELLOW, radius=0.5)
        d.shift(3*RIGHT+0.8*UP)
        self.add(dORIGIN, d)
```



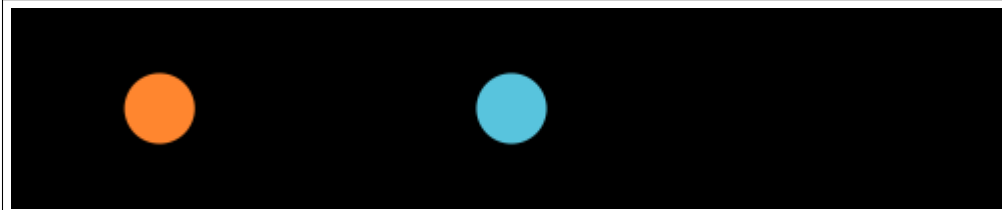
```
[6]: %%manim $param
class Example(Scene):
    def construct(self):
        d= Dot(color= ORANGE, radius=0.5)
        d.next_to(dORIGIN, LEFT)
        self.add(dORIGIN, d)
```



```
[7]: %%manim $param
class Example(Scene):
    def construct(self):
        d= Dot(color= ORANGE, radius=0.5)
        d.next_to(dORIGIN, LEFT, buff=0)
        self.add(dORIGIN, d)
```



```
[8]: %%manim $param
class Example(Scene):
    def construct(self):
        d= Dot(color= ORANGE, radius=0.5)
        d.next_to(dORIGIN, LEFT, buff=4)
        self.add(dORIGIN, d)
```



```
[9]: %%manim $param
class Example(Scene):
    def construct(self):
        d= Dot(color= ORANGE, radius=0.5)
        d.next_to(dORIGIN, UL, buff=-0.5) # UL is UPLEFT
        self.add(dORIGIN, d)
```



```
[10]: %%manim $param
class Example(Scene):
    def construct(self):
```

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```
d= Dot(color= ORANGE, radius=0.5)
d.to_edge(LEFT)
self.add(dORIGIN, d)
```



```
[11]: %%manim $param
class Example(Scene):
    def construct(self):
        s= Star(stroke_width=10)
        d=Dot(color= ORANGE, radius=0.5)
        d.align_to(s,DOWN)
        self.add(s,d)
```



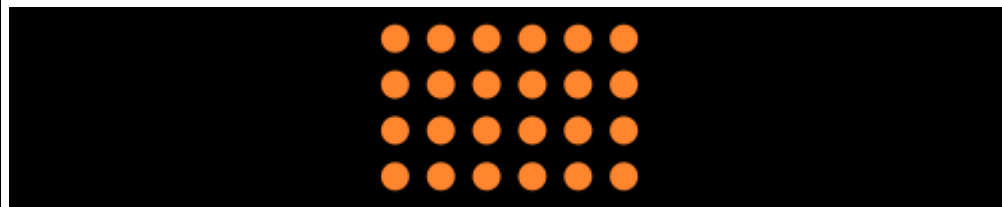
```
[12]: %%manim $param
class Example(Scene):
    def construct(self):
        s= Star(stroke_width=10)
        d=Dot(color= ORANGE, radius=0.5)
        d.next_to(s,RIGHT, aligned_edge=UP) #next to and align combined
        self.add(s,d)
```



```
[13]: %%manim $param
class Example(Scene):
    def construct(self):
        for i in range(0,10):
            self.add(Dot(color= ORANGE, radius=0.5))
        VGroup(*self.mobjects).arrange()
```



```
[14]: %%manim $param
class Example(Scene):
    def construct(self):
        for i in range(0,24):
            self.add(Dot(color= ORANGE, radius=0.2))
        VGroup(*self.mobjects).arrange_in_grid(cols=6)
```



### get positions

The most important methods to get positions:

get\_center , get\_top , get\_right , get\_start

```
[15]: s= Star(stroke_width=10)
d=Dot(color= YELLOW, radius=0.2)
```

```
[16]: %%manim $param
class Example(Scene):
    def construct(self):
        pos= s.get_center()
        self.add(s, d.move_to(pos))
```



```
[17]: %%manim $param
class Example(Scene):
    def construct(self):
        pos= s.get_center_of_mass()
        self.add(s, d.move_to(pos))
```



```
[18]: %%manim $param
class Example(Scene):
    def construct(self):
        pos= s.get_top()
        self.add(s, d.move_to(pos))
```



```
[19]: %%manim $param
class Example(Scene):
    def construct(self):
        pos= s.get_right()
        self.add(s, d.move_to(pos))
```



```
[20]: %%manim $param
class Example(Scene):
    def construct(self):
        pos= s.get_bottom()
        self.add(s, d.move_to(pos))
```



```
[21]: %%manim $param
class Example(Scene):
    def construct(self):
        pos= s.get_left()
        self.add(s, d.move_to(pos))
```



```
[22]: %%manim $param
class Example(Scene):
    def construct(self):
        pos= s.get_corner(UL)
        self.add(s, d.move_to(pos))
```

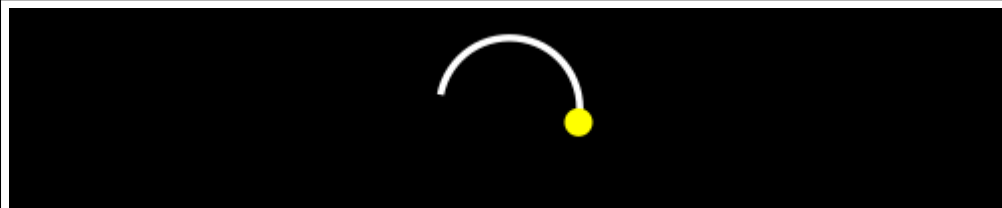


```
[23]: %%manim $param
class Example(Scene):
    def construct(self):
        pos= s.get_corner(DR)
        self.add(s, d.move_to(pos))
```



```
[24]: arc= Arc(radius=1.0, start_angle=-PI/16, angle=PI, stroke_width=10)
```

```
[25]: %%manim $param
class Example(Scene):
    def construct(self):
        pos= arc.get_start()
        self.add(arc, d.move_to(pos))
```



```
[26]: %%manim $param
class Example(Scene):
    def construct(self):
        pos= arc.get_end()
```

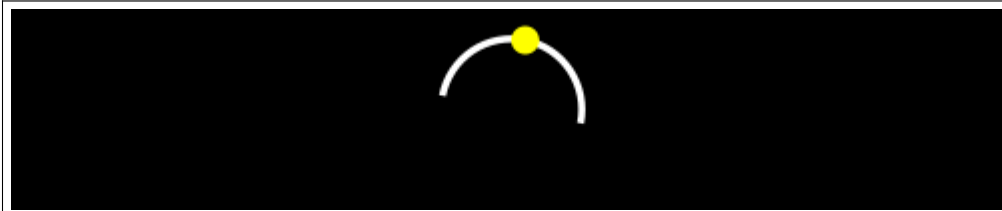
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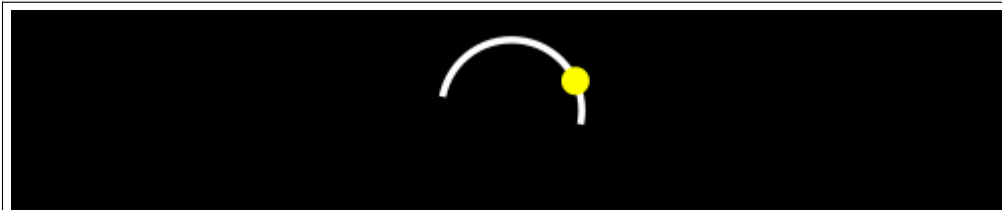
```
self.add(arc, d.move_to(pos))
```



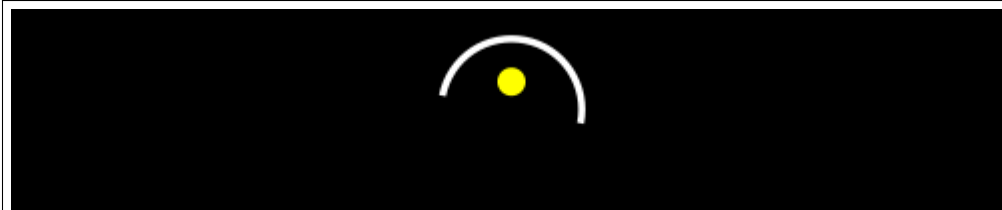
```
[27]: %%manim $param
class Example(Scene):
    def construct(self):
        pos= arc.get_midpoint()
        self.add(arc, d.move_to(pos))
```



```
[28]: %%manim $param
class Example(Scene):
    def construct(self):
        pos= arc.point_from_proportion(0.2)
        self.add(arc, d.move_to(pos))
```



```
[29]: %%manim $param
class Example(Scene):
    def construct(self):
        pos= arc.get_center()
        self.add(arc, d.move_to(pos))
```



```
[30]: %%manim $param
class Example(Scene):
    def construct(self):
        pos= arc.get_center_of_mass()
```

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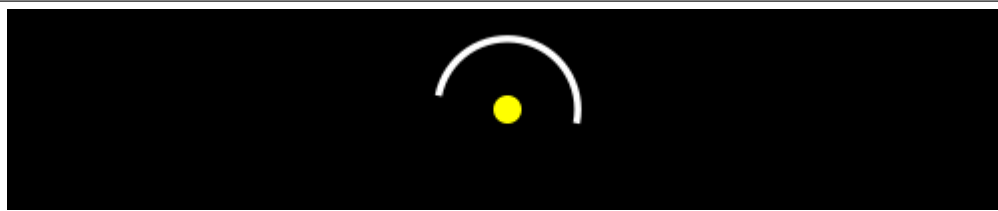


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```
self.add(arc, d.move_to(pos))
```



```
[31]: %%manim $param
class Example(Scene):
    def construct(self):
        pos= arc.get_arc_center()
        self.add(arc, d.move_to(pos))
```



```
[32]: %%manim $param
class Example(Scene): #Example for `get_x`, `get_y`, `set_x` and `set_y`
    def construct(self):
        d = Dot(point=[3,1,0],radius=0.2,color= BLUE)
        triangle= Triangle(color=YELLOW, stroke_width=10).scale(0.5)
        x_pos=d.get_x()
        print(x_pos)
        triangle.set_x(x_pos)
        self.add(d, triangle)
```

```
3.0
```



```
[33]: %%manim $param
class Example(Scene): #Example for `get_x`, `get_y`, `set_x` and `set_y`
    def construct(self):
        d = Dot(point=[3,1,0],radius=0.2,color= BLUE)
        triangle= Triangle(color=YELLOW, stroke_width=10).scale(0.5)
        y_pos=d.get_y()
        print(y_pos)
        triangle.set_y(y_pos)
        self.add(d, triangle)
```

```
1.0
```

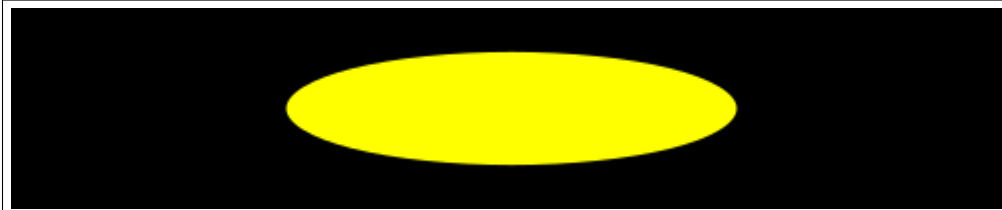


### 1.3.2 Scaling and Stretching

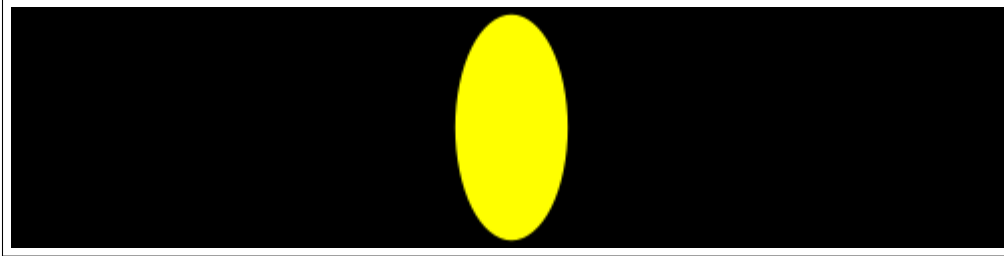
```
[34]: %%manim $param
class Example(Scene):
    def construct(self):
        d= Dot(color= YELLOW)
        d.scale(10)
        self.add(d)
```



```
[35]: %%manim $param
class Example(Scene):
    def construct(self):
        d= Dot(color= YELLOW)
        d.scale(10)
        d.stretch(4, dim = 0) # dim = 0 means vertical
        self.add(d)
```



```
[36]: %%manim $parambigger
class Example(Scene):
    def construct(self):
        d= Dot(color= YELLOW)
        d.scale(10)
        d.stretch(2, dim = 1) # dim = 1 means horizontal
        self.add(d)
```



```
[37]: %%manim $param
class Example(Scene):
    def construct(self):
        d= Dot(color= YELLOW)
        d.scale(10)
        d.apply_matrix([[0.5, 0.5, 0], # shear matrix
                        [ 0 , 1 , 0],
                        [ 0 , 0 , 1]])
        self.add(d)
```



### 1.3.3 Rotating

```
[38]: %%manim $parambigger
class Example(Scene):
    def construct(self):
        m= ManimBanner().scale(0.5)
        m.rotate(PI/8)
        self.add(m)
```



```
[39]: %%manim $parambigger
class Example(Scene):
    def construct(self):
        m= ManimBanner().scale(0.5)
        m.rotate(-20*DEGREES)
        self.add(m)
```



```
[40]: %%manim $parambigger
class Example(Scene):
    def construct(self):
        m= ManimBanner().scale(0.5)
        self.add(m.copy())
        m.rotate(about_point=2*LEFT, angle=180*DEGREES)
        self.add(m, Dot(2*LEFT,radius=0.1))
```



```
[41]: %%manim $parambigger
class Example(Scene):
    def construct(self):
        m= ManimBanner().scale(0.5)
        m.rotate(axis=UP,angle=60*DEGREES)
        self.add(m)
```



#### Note

Python is very fertile tool, there multiple ways to accomplish a certain task, but some options are not “best practice”. For the methods in the next chapters, I want to show the best practice (labeled with **BEST** and the **green check with the star**), other possible options (labeled with **YES** and the **green check**), and options that do not work (labeled with **NO** and the **red cross**)

```
[42]: # ignore this cell, only for setup
YES = SVGObject("good.svg").to_edge(LEFT, buff=1)
BEST = YES.copy()
BEST.add(Star(color= YELLOW, fill_opacity=1).scale(0.5).move_to(BEST).shift(0.5*DOWN+0.
```

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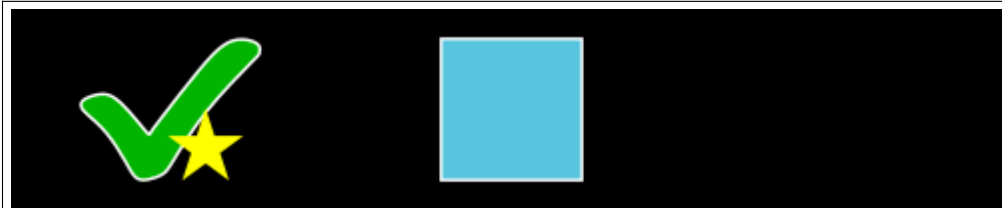
```
→ 5*RIGHT))
NO = Cross(Square(), stroke_color = RED_D, stroke_width = 38).scale(0.9).move_to(YES)
```

### 1.3.4 Colors and Opacity

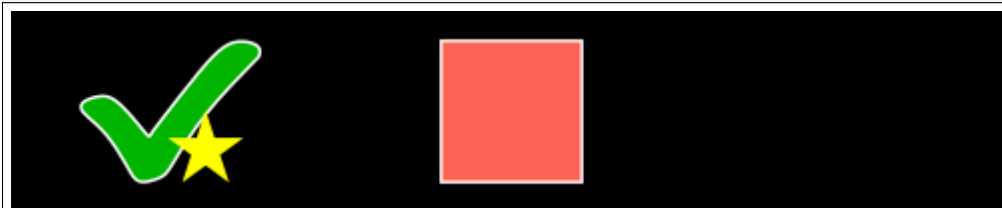
- Color parameters for Mobjects are `stroke_color`, `fill_color` and `color`. The parameter `color` automatically sets both `stroke_color` and `fill_color`.  
The recommended ways to set **colors** are via `c = Circle(fill_color= BLUE, fill_opacity= 1 )`, `c.set_fill(color=RED)` or `c.set_style(fill_color=GREEN)`  
Not possible are `c.fill_color=YELLOW`, `c.set(fill_color=YELLOW)` and `c.set_fill_color(YELLOW)`
- Opacity parameters for Mobjects are `fill_opacity` and `stroke_opacity` (there is **not** opacity here).  
The recommended ways to set **opacity** are via `c = Circle(fill_color= BLUE, fill_opacity= 0.5 )`, `c.set_fill(color=RED)` or `c.set_style(fill_color=GREEN)`  
Analog to colors, `c.fill_opacity=1`, `c.set(fill_opacity=1)` and `c.set_fill_opacity(1)` are not possible. (to keep things short, these examples are not shown).

#### Colors

```
[43]: %%manim $param
class Example(Scene):
    def construct(self):
        c = Square(fill_color= BLUE, fill_opacity= 1 )
        self.add(BEST,c)
```



```
[44]: %%manim $param
class Example(Scene):
    def construct(self):
        c = Square(fill_color= BLUE, fill_opacity= 1)
        c.set_fill(color=RED)
        self.add(BEST,c)
```



```
[45]: %%manim $param
class Example(Scene):
    def construct(self):
```

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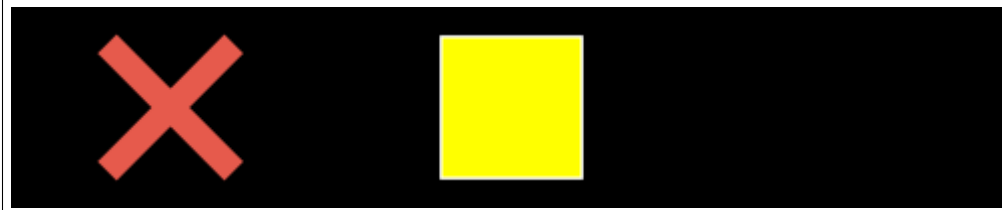
```
c = Square(fill_color= BLUE, fill_opacity= 1)
c.set_style(fill_color=GREEN)
self.add(BEST,c)
```



```
[46]: %%manim $param
class Example(Scene):
    def construct(self):
        c = Square(fill_opacity= 1)
        c.fill_color=YELLOW
        self.add(NO,c)
```

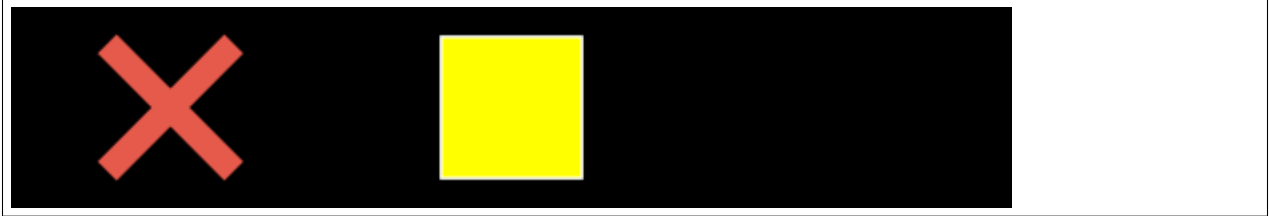


```
[47]: %%manim $param
class Example(Scene):
    def construct(self):
        c = Square(fill_opacity= 1)
        c.set(fill_color=YELLOW)
        self.add(NO,c)
```

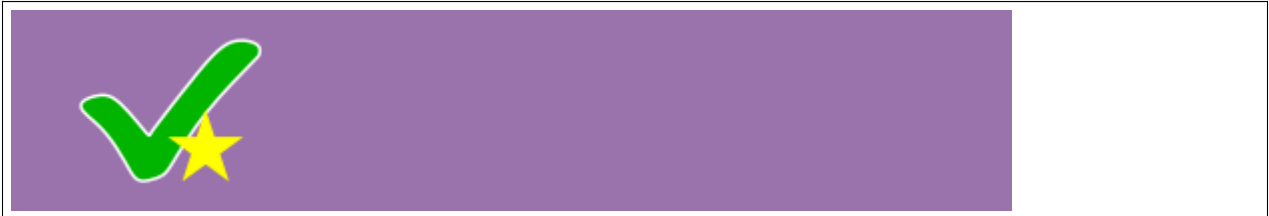


```
[48]: %%manim $param
class Example(Scene):
    def construct(self):
        c = Square(fill_opacity= 1)
        c.set_fill_color(YELLOW)
        self.add(NO,c)
```

```
<string>:4: DeprecationWarning: This method is not guaranteed to stay around. Please
→prefer setting the attribute normally or with Mobject.set().
```

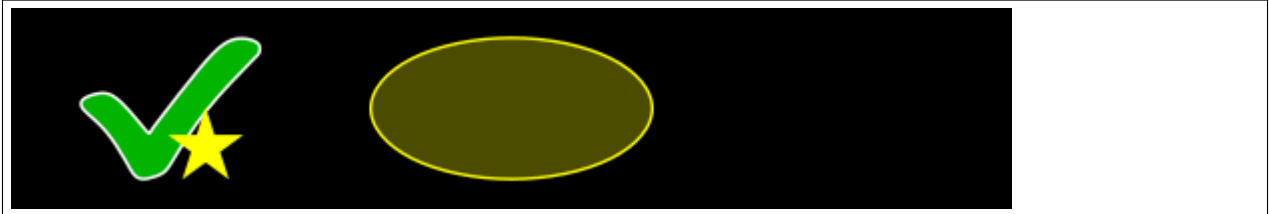


```
[49]: %%manim $param
class Example(Scene):
    def construct(self):
        self.camera.background_color = PURPLE
        self.add(BEST)
```



### Opacity

```
[50]: %%manim $param
class Example(Scene):
    def construct(self):
        c = Ellipse(color= YELLOW, fill_opacity=0.3).scale(2)
        self.add(BEST,c)
```



```
[51]: %%manim $param
class Example(Scene):
    def construct(self):
        c = Ellipse(color= YELLOW).scale(2)
        c.set_fill(opacity=0.5) # be careful: here, it must be `opacity` and not `fill_
        ↪opacity` !
        self.add(BEST,c)
```



```
[52]: %%manim $param
class Example(Scene):
    def construct(self):
        c = Ellipse(color= YELLOW).scale(2)
        c.set_style(fill_opacity=0.7) # and here, it must be `fill_opacity` and not_
        ↪ `opacity` !
        self.add(BEST,c)
```



### 1.3.5 Stroke width

Strokes can be set in multiple ways:

The recommended ways are via `Circle(stroke_width=30)`, `c.set_stroke(width = 30)` or `c.set_style(stroke_width= 30)`

Also possible, but not the best solution is `c.stroke_width = 30` and `c.set(stroke_width = 30)`

Also possible, but not recommended because deprecated is `c.set_stroke_width(30)`

```
[53]: %%manim $param
class Example(Scene):
    def construct(self):
        c = Circle(stroke_width=30)
        self.add(BEST,c)
```



```
[54]: %%manim $param
class Example(Scene):
    def construct(self):
        c = Circle()
        c.set_stroke(width = 30)
        self.add(BEST,c)
```





```
[55]: %%manim $param
class Example(Scene):
    def construct(self):
        c = Circle()
        c.set_style(stroke_width= 30)
        self.add(BEST,c)
```



```
[56]: %%manim $param
class Example(Scene):
    def construct(self):
        c = Circle()
        c.stroke_width = 30
        self.add(YES,c)
```



```
[57]: %%manim $param
class Example(Scene):
    def construct(self):
        c = Circle()
        c.set(stroke_width = 30)
        self.add(YES,c)
```



```
[58]: %%manim $param
class Example(Scene):
    def construct(self):
        c = Circle()
        c.set_stroke_width(30)
        self.add(NO,c)
```

```
<string>:4: DeprecationWarning: This method is not guaranteed to stay around. Please
↳prefer setting the attribute normally or with Mobject.set().
```



### 1.3.6 Layers

There are two main ways to change the layers of Mobjects:

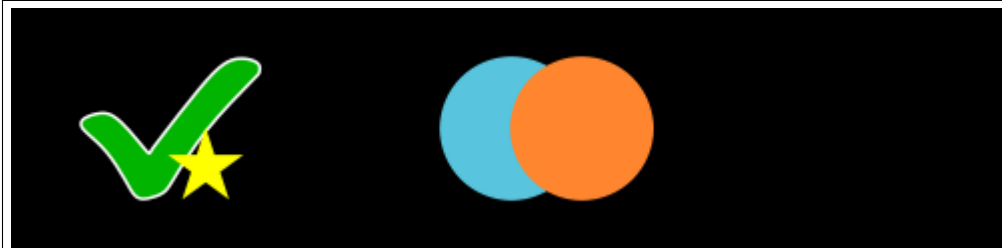
1. Reordering the list of submobjects that were added
2. Using the `z_index`

#### submobjects

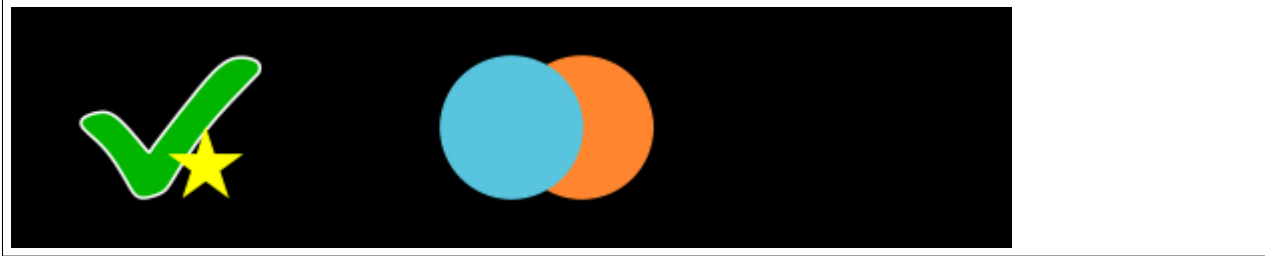
A scene stores displayed mobjects in a list. They are displayed in the order that they are added to the scene with the syntax `self.add(circleLeft, circleRight)`. First, we have a look on positioning mobjects with `self.add` and the methods `self.bring_to_back` and `self.bring_to_front`. In most cases, this is completely enough. Later, we will come to the `z_index`, that is seen by manim by one priority higher: Even when a mobject is added first to the mobject list, it will be displayed on top of the others, if it has a higher `z_index`. An example about this will be seen later.

```
[59]: circleLeft = Circle(color=BLUE, fill_opacity=1)
      circleRight = Circle(color=ORANGE, fill_opacity=1).shift(RIGHT)
      line = Line(2*LEFT, 3*RIGHT, color=YELLOW, stroke_width=20)
```

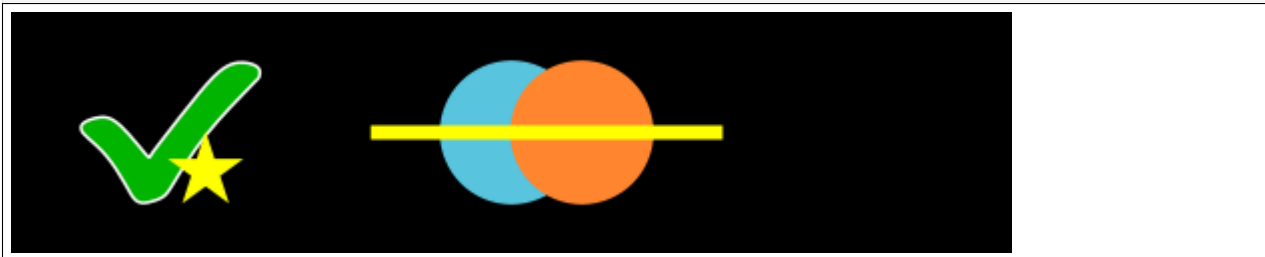
```
[60]: %%manim $parambigger
      class Example(Scene):
          def construct(self):
              self.add(circleLeft, circleRight)
              self.add(BEST)
```



```
[61]: %%manim $parambigger
      class Example(Scene):
          def construct(self):
              self.add(circleRight, circleLeft)
              self.add(BEST)
```

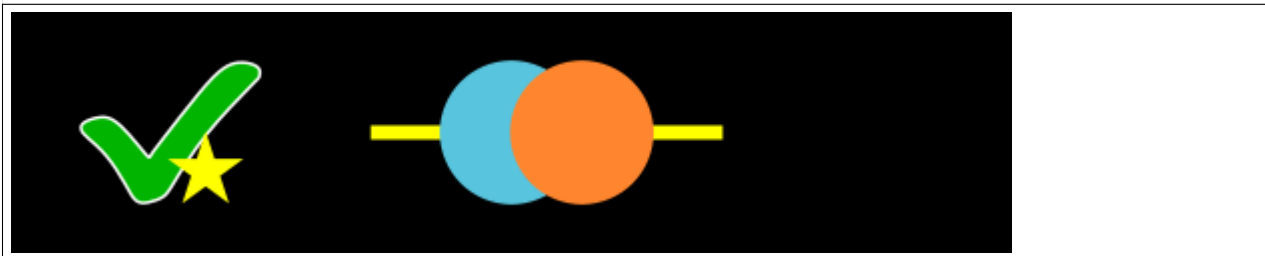


```
[62]: %%manim $parambigger
class Example(Scene):
    def construct(self):
        self.add(circleLeft,circleRight, line)
        self.add(BEST)
```



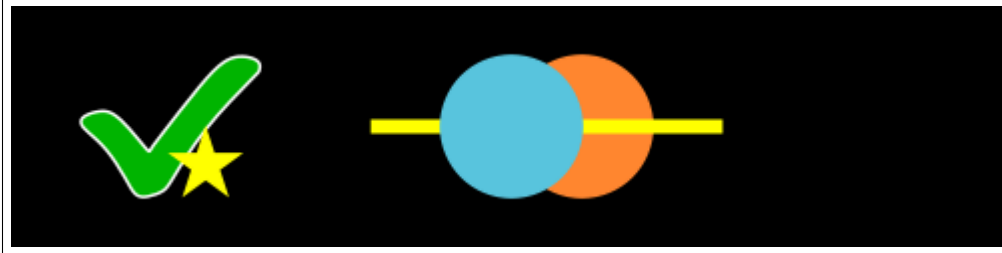
```
[63]: %%manim $parambigger
class Example(Scene):
    def construct(self):
        self.add(circleLeft,circleRight, line)
        print(self.mobjects)
        self.bring_to_back(line)
        print(self.mobjects)
        self.add(BEST)
```

```
[Circle, Circle, Line]
[Line, Circle, Circle]
```



```
[64]: %%manim $parambigger
class Example(Scene):
    def construct(self):
        self.add(circleLeft,circleRight, line)
        print(self.mobjects)
        self.bring_to_front(circleLeft)
        print(self.mobjects)
        self.add(BEST)
```

```
[Circle, Circle, Line]
[Circle, Line, Circle]
```



### z\_index

The default `z_index` is 0. Now we will see what happens, when we increase the value of the `z_index`.

The `z_index` can be changed by `triangle = Triangle(z_index=1)`, `triangle.z_index=1`, `triangle.set(z_index=1)` and `triangle.set_z_index(1)`

It can not be changed using `triangle.set_style(z_index=1)`

```
[65]: #initilizing line,circle,square and triangle
BUFF= 0.5*DOWN
line = Line(3*LEFT,3*RIGHT,color=YELLOW, stroke_width=20)
circle = Circle(color=GREEN_D, fill_opacity=1).shift(LEFT+BUFF)
square = Square(color=BLUE_D, fill_opacity=1).shift(UP+BUFF)
triangle = Triangle(color=RED_D, fill_opacity=1).shift(RIGHT+BUFF)
```

```
[66]: %%manim $parambigger
class Example(Scene):
    def construct(self):
        self.add(line,triangle, square, circle) # order matters
        print(self.mobjects)
        print(f'{triangle.z_index=} , {square.z_index=} , {circle.z_index=} , {line.z_
        ↪index=}')
        self.add(BEST)
```

```
[Line, Triangle, Square, Circle]
triangle.z_index=0 , square.z_index=0 , circle.z_index=0 , line.z_index=0
```



```
[67]: %%manim $parambigger
class Example(Scene):
    def construct(self):
        triangle.z_index=1
        self.add(triangle, square, circle,line) # order matters
```

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```

print(self.mobjects)
print(f"{triangle.z_index=} , {square.z_index=} , {circle.z_index=} , {line.z_
↪index=}")
self.add(BEST)

```

```

[Triangle, Square, Circle, Line]
triangle.z_index=1 , square.z_index=0 , circle.z_index=0 , line.z_index=0

```



```

[68]: %%manim $parambigger
class Example(Scene):
    def construct(self):
        triangle.z_index = 1
        square.z_index    = 2
        circle.z_index    = 3
        self.add(triangle, square, circle, line) # order matters
        self.add(BEST)
        print(f"{line.z_index=}")

```

```
line.z_index=0
```



```

[69]: %%manim $parambigger
class Example(Scene):
    def construct(self):
        triangle.z_index = 3
        square.z_index    = 2
        circle.z_index    = 1
        self.add(triangle, square, circle, line) # order matters
        self.add(BEST)
        print(f"{line.z_index=}")

```

```
line.z_index=0
```



```
[70]: %%manim $parambigger
triangle.z_index = 0
square.z_index   = 0
circle.z_index   = 0
class Example(Scene):
    def construct(self):
        triangle.set(z_index=1)
        self.add(triangle, square, circle, line) # order matters
        print(self.mobjects)
        print(f"{triangle.z_index=} , {square.z_index=} , {circle.z_index=} , {line.z_
→index=}")
        self.add(BEST)
```

```
[Triangle, Square, Circle, Line]
triangle.z_index=1 , square.z_index=0 , circle.z_index=0 , line.z_index=0
```



```
[71]: %%manim $parambigger
triangle.z_index = 0
square.z_index   = 0
circle.z_index   = 0
class Example(Scene):
    def construct(self):
        try:
            triangle.set_style(z_index=1) # here we expect an error! Only for didactic_
→purpose, it is put into this `try` block, so that no long error message is shown.
        except TypeError:
            print("TypeError, set_style() got an unexpected keyword argument 'z_index'.
→")
            self.add(NO)
            self.add(triangle, square, circle, line) # order matters
            print(f"{triangle.z_index=} , {square.z_index=} , {circle.z_index=} , {line.z_
→index=}")
```

```
TypeError, set_style() got an unexpected keyword argument 'z_index'.
triangle.z_index=0 , square.z_index=0 , circle.z_index=0 , line.z_index=0
```



### 1.3.7 VGroup and Group

#### VGroup

It is a Group of VMobjects (“V” stands for Vector)

```
[72]: #only for setup
def create_dots():
    blue1_ref= Dot(color= BLUE,      point=[-.3,-.5,0], radius=0.5)
    blue2_ref= Dot(color= BLUE_A,    point=[ .3,-.5,0], radius=0.5)
    yellow1_ref= Dot(color= YELLOW,   point=[-.3, .5,0], radius=0.5)
    yellow2_ref= Dot(color= YELLOW_A, point=[ .3, .5,0], radius=0.5)
    return blue1_ref, blue2_ref,yellow1_ref,yellow2_ref
```

```
[73]: %%manim $param
blue1,blue2, yellow1,yellow2 = create_dots()
class Example(Scene):
    def construct(self):
        self.add(blue1,blue2, yellow1,yellow2)
```



```
[74]: %%manim $param
blue1,blue2, yellow1,yellow2 = create_dots()
class Example(Scene):
    def construct(self):
        VGroup(yellow1,yellow2).shift(RIGHT)
        self.add(blue1,blue2, yellow1,yellow2)
```



```
[75]: %%manim $param
blue1,blue2, yellow1,yellow2 = create_dots()
class Example(Scene):
    def construct(self):
        g1=VGroup(yellow1,yellow2).shift(2*RIGHT)
        self.add(blue1,blue2, g1)
```



```
[76]: %%manim $param
blue1,blue2, yellow1,yellow2 = create_dots()
class Example(Scene):
    def construct(self):
        g1=VGroup(yellow1,yellow2).set_color(RED)
        self.add(blue1,blue2, g1)
```



```
[77]: %%manim $param
blue1,blue2, yellow1,yellow2 = create_dots()
class Example(Scene):
    def construct(self):
        g1=VGroup(yellow1,yellow2).shift(0.5*DOWN)
        g2=VGroup(blue1,blue2)
        self.add(g1, g2)
```



```
[78]: %%manim $param
blue1,blue2, yellow1,yellow2 = create_dots()
class Example(Scene):
    def construct(self):
        g1=VGroup(yellow1,yellow2).shift(0.5*DOWN)
        g2=VGroup(blue1,blue2)
        self.add(g2,g1)
```



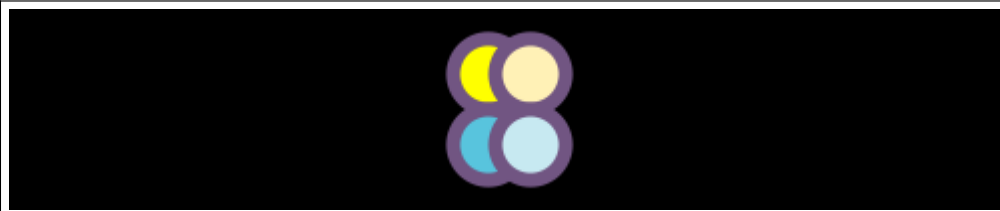


```
[79]: %%manim $param
blue1,blue2, yellow1,yellow2 = create_dots()
class Example(Scene): # Groups of Groups
    def construct(self):
        g1=VGroup(yellow1,yellow2).shift(0.5*DOWN)
        g2=VGroup(blue1,blue2)
        gAll = VGroup(g1, g2)
        self.add(gAll)
        print(gAll.submobjects)
        print(gAll.submobjects[0].submobjects)
        print(gAll.submobjects[1].submobjects)
```

```
[VGroup(Dot, Dot), VGroup(Dot, Dot)]
[Dot, Dot]
[Dot, Dot]
```



```
[80]: %%manim $param
blue1,blue2, yellow1,yellow2 = create_dots()
class Example(Scene): #setting VMobject attributes
    def construct(self):
        g=VGroup(yellow1,yellow2,blue1,blue2)
        g.set_stroke(color=PURPLE_D, width=20) # <--
        self.add(g)
```



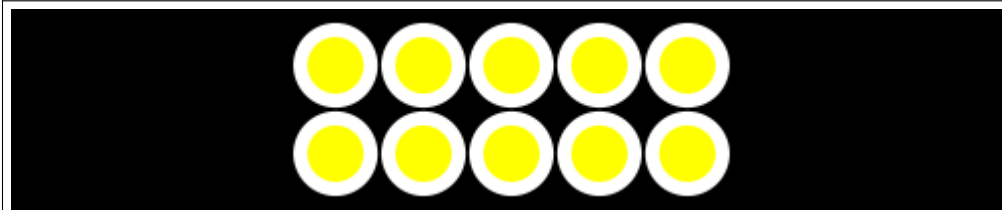
```
[81]: %%manim $param
blue1,blue2, yellow1,yellow2 = create_dots()
class Example(Scene): # add syntax
    def construct(self):
        g=VGroup(yellow1,yellow2,blue1)
        g.add(blue2) # <--
        g.set_stroke(color=GREEN, width=20)
        self.add(g)
```



```
[82]: %%manim $param
blue1,blue2, yellow1,yellow2 = create_dots()
class Example(Scene): # += Syntax
    def construct(self):
        g=VGroup(yellow1,yellow2,blue1)
        g += blue2 # <--
        g.set_stroke(color=ORANGE, width=20)
        self.add(g)
```



```
[83]: %%manim $param
blue1,blue2, yellow1,yellow2 = create_dots()
class Example(Scene): # empty initilizing
    def construct(self):
        g=VGroup()
        for _ in range(0,10):
            g += yellow1.copy()
        g.set_stroke(color=WHITE, width=20)
        g.arrange_in_grid(rows=2) # <-- Groups and VGroups can be arranged in grids
        g.move_to(ORIGIN)
        self.add(g)
```



Note:

`VObject().add(...)` is functionally equivalent to `VGroup(...)`, but it is recommended to use `VGroup`, as

- It is better readable
- supports the += syntax

```
[84]: %%manim $param
```

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```

blue1,blue2, yellow1,yellow2 = create_dots()
class Example(Scene): # using VMOBJECT instead
    def construct(self):
        g= VMobject()
        g.add(yellow1,yellow2,blue1,blue2)
        g.set_stroke(color=PURPLE_D, width=20)
        self.add(g)

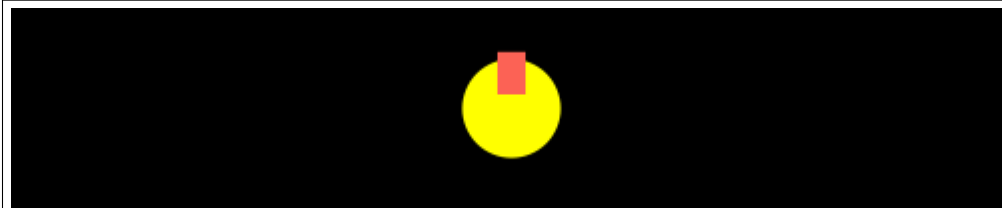
```



```

[85]: %%manim $param
blue1,blue2, yellow1,yellow2 = create_dots()
class Example(Scene): # other Mobjects can be added to any Mobjects
    def construct(self):
        d= Dot(color= YELLOW, radius=0.7)
        d.add(Line(0.2*UP, 0.8*UP, color=RED,stroke_width=40))
        self.add(d)

```



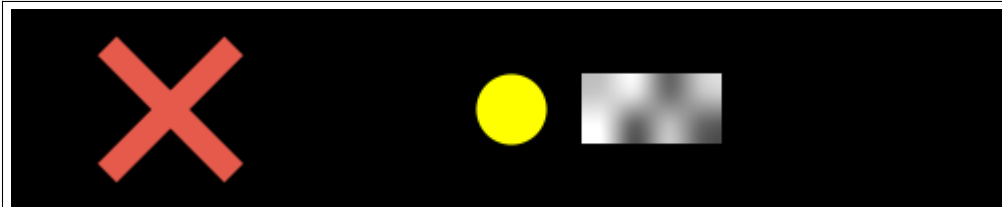
```

[86]: %%manim $param
dot= Dot(color= YELLOW, radius=0.5)
image = ImageMobject(np.uint8([[200, 233, 111, 200],
                                [255, 100, 190, 100]])).shift(2*RIGHT)

image.height = 1
class Example(Scene):
    def construct(self):
        self.add(dot, image)
        try: # Image is not a VMobject!
            VGroup(dot,image).shift(3*RIGHT)
        except TypeError:
            print("Adding an Mobject to a VGroup is not possible!")
            self.add(NO)

```

Adding an Mobject to a VGroup is not possible!

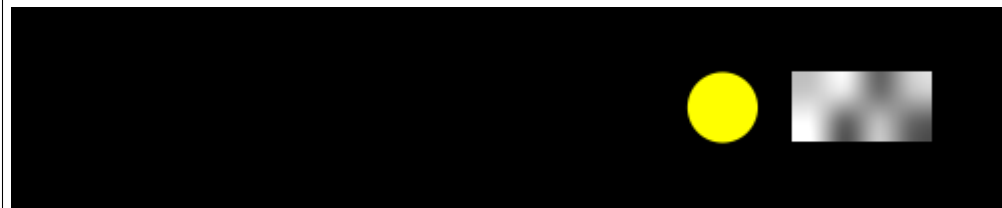


### Group

Groups Mobjects and VMobjects together. You can only use the methods of Mobject here. Methods of VMobject won't be supported.

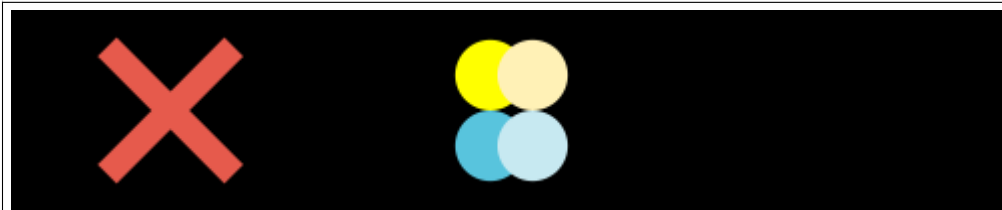
```
[87]: %%manim $param
dot= Dot(color= YELLOW, radius=0.5)
image = ImageMobject(np.uint8([[200, 233, 111, 200],
                                [255, 100, 190, 100]])).shift(2*RIGHT)

image.height = 1
class Example(Scene):
    def construct(self):
        self.add(dot, image)
        Group(dot, image).shift(3*RIGHT)
```



```
[88]: %%manim $param
blue1,blue2, yellow1,yellow2 = create_dots()
class Example(Scene): #
    def construct(self):
        g=Group(yellow1,yellow2,blue1,blue2)
        try:
            g.set_stroke(color=PURPLE_D, width=20)
        except TypeError:
            print("TypeError!")
            self.add(NO)
        self.add(g)
```

TypeError!



---

Note: `z_index` is not supported, neither for `VGroup` nor for `Group`

---

```
[89]: %%manim $param
blue1,blue2, yellow1,yellow2 = create_dots()
class Example(Scene):
    def construct(self):
        a=VGroup(yellow1,yellow2).shift(0.5*DOWN)
        b=VGroup(blue1,blue2)
        a.set_z_index(2)
```

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```
b.set_z_index(1)
self.add(a,b)
self.add(NO)
```



### 1.3.8 Making Mobject Classes

```
[90]: param = "-v WARNING -s -r 300,100 --disable_caching --progress_bar None Example"
```

```
[91]: %%manim $param
class Example(Scene):
    def construct(self):
        d1 = Dot(point= [0,0,0], radius=2)
        d2 = Dot(point= [1,0,0], radius=2)
        diff = Difference(d1,d2,fill_opacity=1,stroke_width=0)
        self.add(diff)
```



```
[92]: %%manim $param
class Moon(VGroup):
    def __init__(self):
        super().__init__()
        d1 = Dot(point= [0,0,0], radius=2)
        d2 = Dot(point= [1,0,0], radius=2)
        diff = Difference(d1,d2,fill_opacity=1,stroke_width=0, fill_color=BLUE)
        self.add(diff)

class Example(Scene):
    def construct(self):
        m = Moon()
        self.add(m)
```



Note: Replacing `super().__init__()` with `VGroup().__init__(self)` would also work, but is discouraged to use.

Note: The class can be of type `VGroup`, `Group`, `VMobject`, and `Mobject`. It depends on what class features you want to use when choosing the classtype. `VGroup` is recommended.

```
[93]: %%manim $param
class Moon(VGroup): # <- Try what happens when you change it to VMobject
    def __init__(self):
        super().__init__()
        d1 = Dot(point= [0,0,0], radius=2)
        d2 = Dot(point= [1,0,0], radius=2)
        diff = Difference(d1,d2,fill_opacity=1,stroke_width=0, fill_color=BLUE)
        self.add(diff)

class Example(Scene):
    def construct(self):
        m = Moon()
        m += Line(stroke_width=40, color=BLUE_E)
        self.add(m)
```



```
[94]: %%manim $param
class Moon(VGroup):
    def __init__(self,moon_color): # <- here one can init the classes with certain
    ↪parameters.
        super().__init__()
        d1 = Dot(point= [0,0,0], radius=2)
        d2 = Dot(point= [1,0,0], radius=2)
        diff = Difference(d1,d2,fill_opacity=1, fill_color= moon_color) # <- here the
    ↪parameter is used
        self.add(diff)

class Example(Scene):
    def construct(self):
        m = Moon(moon_color=YELLOW) # <- here the parameter is used
        self.add(m)
```



---

Congratulations!

You are now a master in setting up your Mobjects on a scene. Let's go on with the part you came to manim for in the

first place: Animations!

## 1.4 Animations

There are a wide range of possibilities to animate your mobjects that all work a bit differently. Here is a broad overview so that you can choose the animation strategy that fits best for your project. This chapter will cover ValueTrackers, Updaters, self.play Transformations the mobject.animate syntax and mobject.become syntax.

```
[1]: from manim import *
      config.media_embed = True
```

Manim Community v0.17.1

```
[2]: #ignore this cell, only for setup
      param= "-v WARNING --progress_bar None -r 500,200 --disable_caching Example"

      NO = Cross(Square(), stroke_color = RED_D, stroke_width = 38).scale(0.9).to_edge(LEFT, buff=1)
      YES = SVGObject("good.svg").to_edge(LEFT, buff=1)
      BEST = YES.copy()
      BEST.add(Star(color= YELLOW, fill_opacity=1).scale(0.5).move_to(BEST).shift(0.5*DOWN+0.5*RIGHT));
```

### 1.4.1 Simple Replacements

```
[3]: %%manim $param
      class Example(Scene):
          def construct(self):
              dot= Dot(color= YELLOW, radius=0.5)
              self.add(dot)
              self.wait()
              dot.scale(2)
              self.wait()
              dot.scale(2)
              self.wait(2)
```

<IPython.core.display.Video object>

```
[4]: %%manim $param
      class Example(Scene):
          def construct(self):
              dot= Dot(color= YELLOW, radius=0.5)
              square= Square(side_length=4,color= BLUE, fill_opacity=1)
              triangle= Triangle(radius=3,color= ORANGE, fill_opacity=1).shift(DOWN*0.5)
              self.add(dot)
              self.wait()
              dot.become(square)
```

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```
self.wait()
dot.become(triangle)
self.wait()
```

```
<IPython.core.display.Video object>
```

## 1.4.2 Using .animate Syntax

```
[5]: %%manim $param
class Example(Scene):
    def construct(self):
        dot= Dot(color= YELLOW, radius=0.5)
        self.play(dot.animate.scale(2))
```

```
<IPython.core.display.Video object>
```

```
[6]: %%manim $param
class Example(Scene):
    def construct(self):
        dot= Dot(color= YELLOW, radius=0.5)
        self.play(dot.animate.shift(2*RIGHT))
```

```
<IPython.core.display.Video object>
```

```
[7]: %%manim $param
class Example(Scene):
    def construct(self):
        dot= Dot(color= YELLOW, radius=0.5)
        self.play(dot.animate.set_color(BLUE))
```

```
<IPython.core.display.Video object>
```

```
[8]: %%manim $param
class Example(Scene):
    def construct(self):
        dot= Dot(color= YELLOW, radius=0.5)
        self.play(dot.animate.shift(2*RIGHT).scale(2))
```

```
<IPython.core.display.Video object>
```

```
[9]: %%manim $param
class Example(Scene):
    def construct(self):
        dot= Dot(color= YELLOW, radius=0.5)
        self.play(dot.animate.shift(2*RIGHT).scale(2).set_color(BLUE))
```

```
<IPython.core.display.Video object>
```



### 1.4.3 Updaters

They are very diverse! And they can be used with and without a “dt” parameter

```
[10]: %%manim $param
class Example(Scene):
    def construct(self):
        dot = Dot(color= GREEN, radius=0.7)
        self.add(dot)
        def foo(mob,dt):
            mob.shift(2*RIGHT*dt)
            dot.add_updater(foo)
        self.wait(3)

<IPython.core.display.Video object>
```

```
[11]: %%manim $param
class Example(Scene):
    def construct(self):
        dot = Dot(color= GREEN, radius=0.7)
        self.add(dot)
        dot.add_updater(lambda x,dt: x.shift(2*RIGHT*dt))
        self.wait(3)

<IPython.core.display.Video object>
```

```
[12]: %%manim $param
class Example(Scene): # when there is no dt parameter, the updater does not work
    def construct(self):
        dot = Dot(color= GREEN, radius=0.7)
        self.add(dot,NO)
        dot.add_updater(lambda x : x.shift(2*RIGHT*0.1))
        self.wait(3)

<IPython.core.display.Video object>
```

Note: Not using the “dt” parameter will make your animation framerate dependent, but this can be solved using ValueTracker, which can be seen in the next section

### 1.4.4 Updaters + ValueTrackers

```
[13]: %%manim $param
class Example(Scene):
    def construct(self):
        tracker= ValueTracker(0)
        dot = Dot(color= GREEN, radius=0.7)
        self.add(dot)
        def foo(mob):
            mob.move_to(RIGHT*tracker.get_value())
            dot.add_updater(foo)
        self.play(tracker.animate.set_value(2), rate_func= linear)

<IPython.core.display.Video object>
```

Note: now you can also use rate functions:

```
[14]: %%manim $param
class Example(Scene):
    def construct(self):
        tracker= ValueTracker(0)
        dot = Dot(color= GREEN, radius=0.7)
        self.add(dot)
        def foo(mob):
            mob.move_to(RIGHT*tracker.get_value())
        dot.add_updater(foo)
        self.play(tracker.animate.set_value(2), rate_func= smooth)

<IPython.core.display.Video object>
```

and this is how to make a custom rate function, e.g. a for a low frame rate within a high frame rate video:

```
[15]: %%manim $param

def low_frame_rate(t):
    return np.floor(t*10)/10

class Example(Scene):
    def construct(self):
        self.camera.background_color = "#ece6e2"
        banner = ManimBanner(dark_theme=False).scale(0.7)
        banner2 = banner.copy()
        Group(banner, banner2).arrange(DOWN)
        self.play(banner.expand(), rate_func = low_frame_rate)
        self.play(banner2.expand())
        self.wait()

<IPython.core.display.Video object>
```

```
[16]: %%manim $param
class Example(Scene):
    def construct(self):
        tracker= ValueTracker(0.5)
        dot = Dot(color= GREEN, radius=0.7)
        self.add(dot)
        def foo(mob):
            mob.move_to(RIGHT*tracker.get_value())
        dot.add_updater(foo)
        self.play(tracker.animate.set_value(2.2), rate_func= smooth)
        self.play(tracker.animate.increment_value(1), rate_func= smooth)
        self.play(tracker.animate.increment_value(-1), rate_func= smooth)
        self.play(tracker.animate.set_value(0.5), rate_func= linear)

<IPython.core.display.Video object>
```

It's also possible to use different rate functions simultaneously:

```
[17]: %%manim $param
class Example(Scene):
    def construct(self):
```

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```

line1 = Line(3*LEFT, 3*RIGHT, stroke_width=10).set_color(RED)
line2 = Line(3*LEFT, 3*RIGHT, stroke_width=10).set_color(GREEN)
Group(line1,line2).arrange(DOWN, buff=2)

d1 = Dot(point = line1.get_left(), radius=0.5)
d2 = Dot(point = line2.get_left(), radius=0.5)

label1 = Tex("smooth").scale(2).next_to(line1, buff= 1)
label2 = Tex("linear").scale(2).next_to(line2, buff= 1)

tr1=ValueTracker(-3)
tr2=ValueTracker(-3)

d1.add_updater(lambda z: z.set_x(tr1.get_value()))
d2.add_updater(lambda z: z.set_x(tr2.get_value()))

self.add(line1,line2,d1,d2,label1,label2 )

self.play(tr1.animate(rate_func=smooth).set_value(3), tr2.animate(rate_
↪func=linear).set_value(3))
self.wait()

<IPython.core.display.Video object>

```

```

[18]: %%manim $param
#one can now also add additional properties to mobjects, in this case a counter.
class Example(Scene):
    def construct(self):
        tracker= ValueTracker(0)
        dot = Dot(color= GREEN, radius=0.7)
        self.add(dot)
        dot.counter=0
        def foo(mob):
            mob.move_to(RIGHT*tracker.get_value())
            if mob.counter == 20:
                mob.set_color(random_bright_color())
                mob.counter = 0
            mob.counter += 1
        dot.add_updater(foo)
        self.play(tracker.animate.set_value(2), rate_func= linear, run_time=3)

<IPython.core.display.Video object>

```

### 1.4.5 Transformations

```
[19]: %%manim $param
class Example(Scene):
    def construct(self):
        d= Dot(color= YELLOW, radius=0.5)
        d2= d.copy().shift(2*RIGHT)
        self.play(Transform(d, d2))
```

```
<IPython.core.display.Video object>
```

### 1.4.6 Does and Donts

Note that when you choose to work with updaters, your script might depend on the frame rate.

```
[20]: %%manim $param
class Example(Scene):
    def construct(self):
        print(f"{config.frame_rate = }fps")
        dotred= Dot(color= RED, radius=0.5).shift(UP)
        dotgreen = Dot(color= GREEN, radius=0.5)
        dotgreen.next_to(dotred,DOWN)
        self.add(dotgreen,dotred)
        DIR= 2*RIGHT
        dotgreen.add_updater(lambda x,dt: x.shift(DIR*dt))
        dotred.add_updater(lambda x,dt: x.shift(DIR*1/60))
        self.wait(3)
```

```
config.frame_rate = 60fps
```

```
<IPython.core.display.Video object>
```

```
[21]: param5fps = "-v WARNING --progress_bar None --frame_rate=5 -r 500,200 --disable_
↪ caching Example"
```

```
[22]: %%manim $param5fps
class Example(Scene):
    def construct(self):
        print(f"{config.frame_rate = }fps")
        dotred= Dot(color= RED, radius=0.5).shift(UP)
        dotgreen = Dot(color= GREEN, radius=0.5)
        dotgreen.next_to(dotred,DOWN)
        self.add(dotgreen,dotred)
        DIR= 2*RIGHT
        dotgreen.add_updater(lambda x,dt: x.shift(DIR*dt))
        dotred.add_updater(lambda x,dt: x.shift(DIR*1/60))
        self.wait(3)
```

```
config.frame_rate = 5.0fps
```

```
<IPython.core.display.Video object>
```

## Rotation animation

There are multiple ways to rotate a square, but not all will result in that animation that you might have expected.

[23]: %%manim \$param

```
class Example(Scene):
    def construct(self, **kwargs):
        s1= Square().set_color(YELLOW)
        self.add(s1, BEST)
        self.play(Rotate(s1, angle=PI/2))
```

<IPython.core.display.Video object>

[24]: %%manim \$param

```
class Example(Scene):
    def construct(self, **kwargs):
        s2= Square().set_color(PURPLE)
        self.add(s2, NO)
        self.play(s2.animate.rotate(PI/2))
```

<IPython.core.display.Video object>

[25]: %%manim \$param

```
class Example(Scene):
    def construct(self, **kwargs):
        theta_track= ValueTracker(0)
        s3= Square().set_color(ORANGE)
        self.add(s3, YES)
        s3.previous_angle=0
        def pref(x):
            x.previous_angle=theta_track.get_value()
        s3.add_updater(lambda x: x.rotate(theta_track.get_value()-s3.previous_angle))
        s3.add_updater(pref)
        self.play(theta_track.animate.increment_value(PI/2))
```

<IPython.core.display.Video object>

[26]: #not yet implemented

```
#class Example(Scene):
#    def construct(self, **kwargs):
#        #s3b= Square().set_color(YELLOW)
#        #self.add(s3b)
#        #theta_track= DeltaValueTracker(0)
#        #s3b.add_updater(lambda x: x.rotate(theta_track.get_delta_value()))
#        #self.play(theta_track.animate.set_value(90*DEGREES))
```

[27]: %%manim \$param

```
# NOT WORKING!, BAD PRACTICE.
class Example(Scene):
    def construct(self, **kwargs):
        s4= Square().set_color(GREEN)
```

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```

self.add(s4, NO)
theta_track= ValueTracker(0)
s4.add_updater(lambda x: x.rotate(theta_track.get_value()))
self.play(theta_track.animate.increment_value(PI/2))

```

<IPython.core.display.Video object>

```

[28]: %%manim $param
class Example(Scene):
    def construct(self, **kwargs):
        s6= Square().set_color(PINK)
        self.add(s6, YES)
        s6.add_updater(lambda x, dt: x.rotate(dt*PI/2))
        self.wait(1)

```

<IPython.core.display.Video object>

## Known bugs

### Bug with updaters that do not have a dt

```

[29]: %%manim $param
class Example(Scene):
    def construct(self):
        dot = Dot(color= GREEN, radius=0.7)
        self.add(dot,NO)

        #dot.add_updater(lambda x,dt : x)

        dot.add_updater(lambda x : x.shift(2*RIGHT*1/config.frame_rate))
        self.wait(3)

```

<IPython.core.display.Video object>

```

[30]: %%manim $param
class Example(Scene):
    def construct(self):
        dot = Dot(color= GREEN, radius=0.7)
        self.add(dot,YES)

        dot.add_updater(lambda x,dt : x) #adding this line will make the updater_
↪continiously watch

        dot.add_updater(lambda x : x.shift(2*RIGHT*1/config.frame_rate))
        self.wait(3)

```

<IPython.core.display.Video object>

## Bugs with updater in ZoomedScene

```
[31]: %%manim $param
class Example(ZoomedScene):
    def __init__(self, **kwargs):
        ZoomedScene.__init__(
            self,
            zoom_factor=0.3,
            zoomed_display_height=4,
            zoomed_display_width=4,
            image_frame_stroke_width=20,
            zoomed_camera_config={
                "default_frame_stroke_width": 3,
            },
            **kwargs
        )
    def construct(self):
        d= Dot()
        self.add(d)
        imgo =Square().scale(0.3).set_color(RED)
        self.add(imgo)
        #imgo.add_updater(lambda x: x) # COMMENTED OUT
        self.activate_zooming(animate=True)
        self.play(self.zoomed_camera.frame.animate.shift(0.5 * (LEFT+UP*0.8)))
        self.play(self.zoomed_camera.frame.animate.shift(0.5 * (RIGHT+DOWN*2.8)))

<IPython.core.display.Video object>
```

```
[32]: %%manim $param
class Example(ZoomedScene):
    def __init__(self, **kwargs):
        ZoomedScene.__init__(
            self,
            zoom_factor=0.3,
            zoomed_display_height=4,
            zoomed_display_width=4,
            image_frame_stroke_width=20,
            zoomed_camera_config={
                "default_frame_stroke_width": 3,
            },
            **kwargs
        )
    def construct(self):
        d= Dot()
        self.add(d)
        imgo =Square().scale(0.3).set_color(RED)
        self.add(imgo)
        imgo.add_updater(lambda x: x) # INCLUDED
        self.activate_zooming(animate=True)
        self.play(self.zoomed_camera.frame.animate.shift(0.5 * (LEFT+UP*0.8)))
        self.play(self.zoomed_camera.frame.animate.shift(0.5 * (RIGHT+DOWN*2.8)))

<IPython.core.display.Video object>
```

## 1.5 Resolution and Camera

```
[1]: from manim import *
      config.media_embed = True

      Manim Community v0.17.1
```

### 1.5.1 Scene Coordinates

First, let's learn a bit about how manim coordinates work.

There is the `config.frame_width`, `config.frame_height` which is unrelated to the pixelsize.

Their default values are 14.222 and 8.

These values are chosen, because it gives a width/height ratio of 16/9, which is a common screen resolution.

The coordinate center of scenes is in the center, which is at **(0,0)**.

The most left point is **(-7.1,0)**, right is **(7.1,0)**, top is **(0,4)**, and bottom is **(0,-4)**.

```
[2]: config.frame_width/config.frame_height
```

```
[2]: 1.7777777777777777
```

```
[3]: config.pixel_width/config.pixel_height
```

```
[3]: 1.7777777777777777
```

```
[4]: 16/9
```

```
[4]: 1.7777777777777777
```

```
[5]: # for setup only
      def yellow_frame_annotation(framew, frameh):
          d1 = DoubleArrow(framew * LEFT / 2, framew * RIGHT / 2, buff=0).to_edge(DOWN)
          t1 = Text(str(framew)[:6]).next_to(d1, UP)
          d2 = DoubleArrow(frameh * UP / 2, frameh * DOWN / 2, buff=0).to_edge(LEFT)
          t2 = Text(str(frameh)).next_to(d2, RIGHT)
          x=Group(d1,d2,t1,t2).set_color(YELLOW)
          return x

      def blue_pixel_annotation(framew, frameh, pixelw, pixelh):
          d1 = DoubleArrow(framew * LEFT / 2, framew * RIGHT / 2, buff=0).to_edge(UP)
          t1 = Text(str(pixelw) + " pixel").next_to(d1, DOWN)
          d2 = DoubleArrow(frameh * UP / 2, frameh * DOWN / 2, buff=0).to_edge(RIGHT)
          t2 = Text(str(pixelh) + " pixel").next_to(d2, LEFT)
          x=Group(d1,d2,t1,t2).set_color(BLUE)
          return x

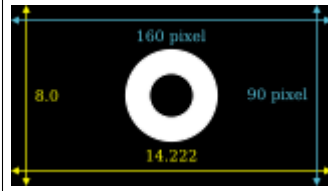
      annulus = Annulus(inner_radius =1,outer_radius=2,color=WHITE, stroke_width=10)
```



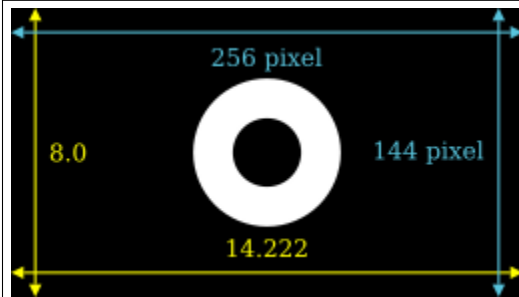
## Pixel Ratio of 16/9

See a table of common 16/9 resolutions here: [https://en.wikipedia.org/wiki/16:9\\_aspect\\_ratio#Common\\_resolutions](https://en.wikipedia.org/wiki/16:9_aspect_ratio#Common_resolutions)

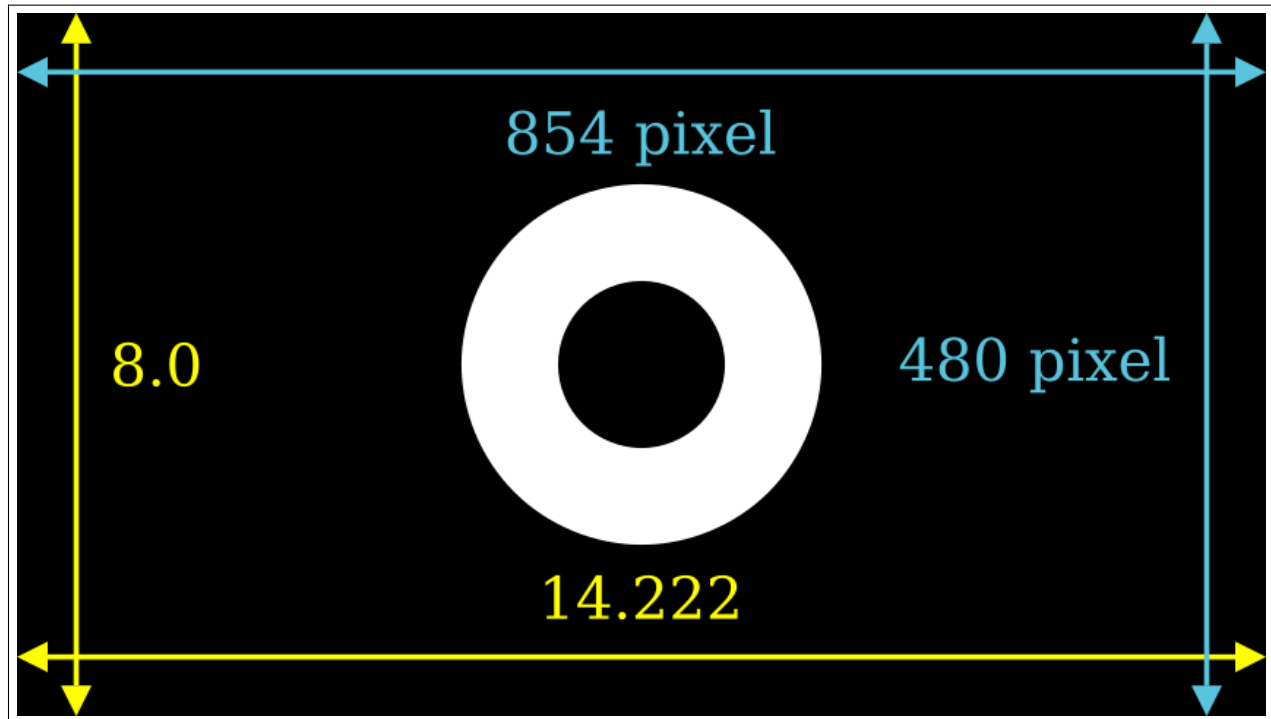
```
[6]: %%manim -v WARNING -s -r 160,90 --disable_caching Example
class Example(Scene):
    def construct(self):
        frame_annotation= yellow_frame_annotation(config.frame_width,config.frame_height)
        pixel_annotation= blue_pixel_annotation(config.frame_width,config.frame_height,
        ↪ config.pixel_width,config.pixel_height)
        self.add(frame_annotation, pixel_annotation, annulus)
```



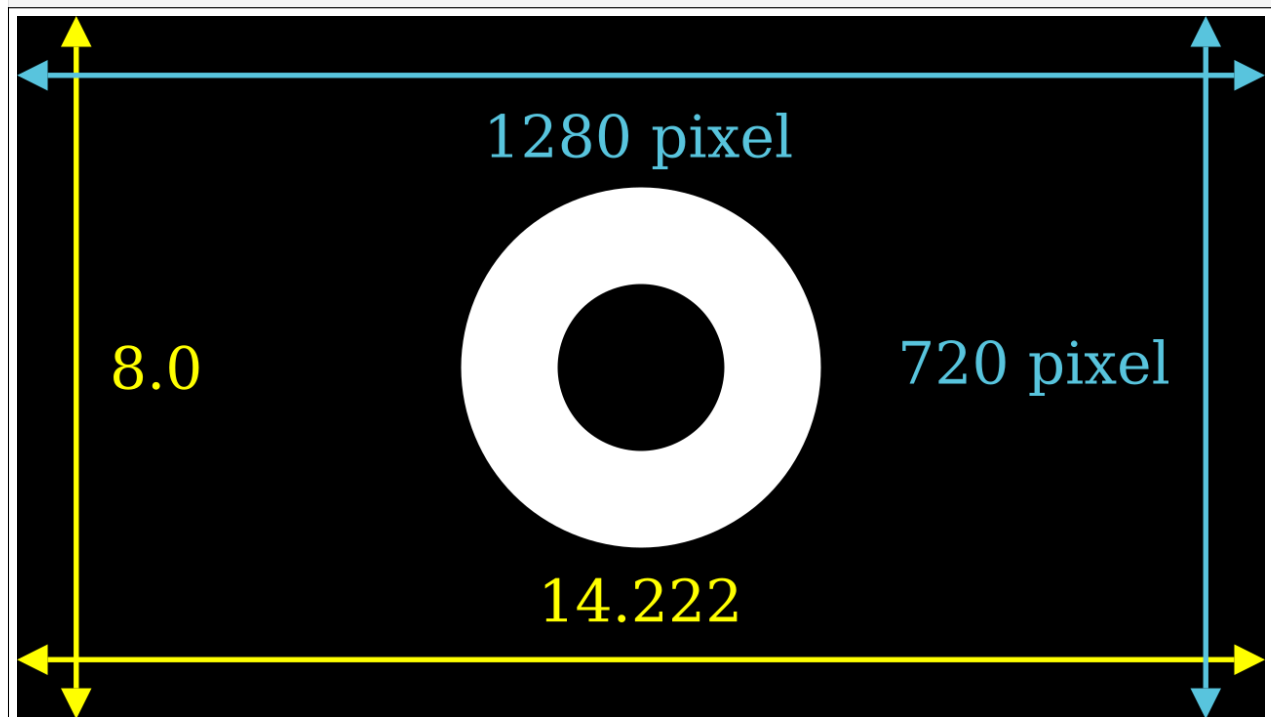
```
[7]: %%manim -v WARNING -s -r 256,144 --disable_caching Example
class Example(Scene):
    def construct(self):
        frame_annotation= yellow_frame_annotation(config.frame_width,config.frame_height)
        pixel_annotation= blue_pixel_annotation(config.frame_width,config.frame_height,
        ↪ config.pixel_width,config.pixel_height)
        self.add(frame_annotation, pixel_annotation, annulus)
```



```
[8]: %%manim -v WARNING -s -ql --disable_caching Example
class Example(Scene):
    def construct(self):
        frame_annotation= yellow_frame_annotation(config.frame_width,config.frame_height)
        pixel_annotation= blue_pixel_annotation(config.frame_width,config.frame_height,
        ↪ config.pixel_width,config.pixel_height)
        self.add(frame_annotation, pixel_annotation, annulus)
```



```
[9]: %%manim -v WARNING -s -qm --disable_caching Example
class Example(Scene):
    def construct(self):
        frame_annotation= yellow_frame_annotation(config.frame_width,config.frame_height)
        pixel_annotation= blue_pixel_annotation(config.frame_width,config.frame_height,
        ↪config.pixel_width,config.pixel_height)
        self.add(frame_annotation, pixel_annotation, annulus)
```



---

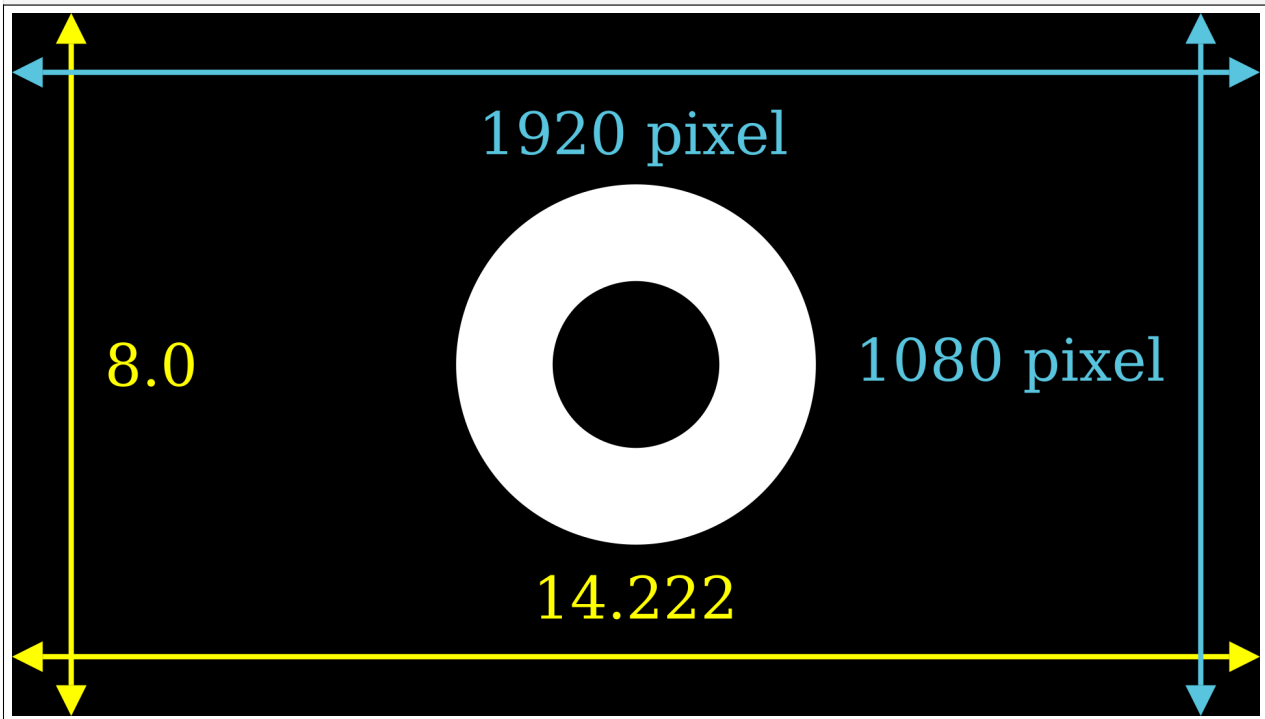
Note

The borders of this website are narrow.

To see the changes in high resolution, open this image in a new tab.

---

```
[10]: %%manim -v WARNING -s -qh --disable_caching Example
class Example(Scene):
    def construct(self):
        frame_annotation= yellow_frame_annotation(config.frame_width,config.frame_height)
        pixel_annotation= blue_pixel_annotation(config.frame_width,config.frame_height,
        ↪config.pixel_width,config.pixel_height)
        self.add(frame_annotation, pixel_annotation, annulus)
```



### Pixel Ratio Unequal to 16/9

- When the pixel ratio is heigher then 16/9 frame\_height cropped.
- When the pixel ratio is lower then 16/9 frame\_height padded.

```
[11]: %%manim -v WARNING -s -r 1000,500 --disable_caching Example
#ratio of 2/1
class Example(Scene):
    def construct(self):
        frame_annotation= yellow_frame_annotation(config.frame_width,config.frame_height)
        pixel_annotation= blue_pixel_annotation(config.frame_width,config.frame_height,
```

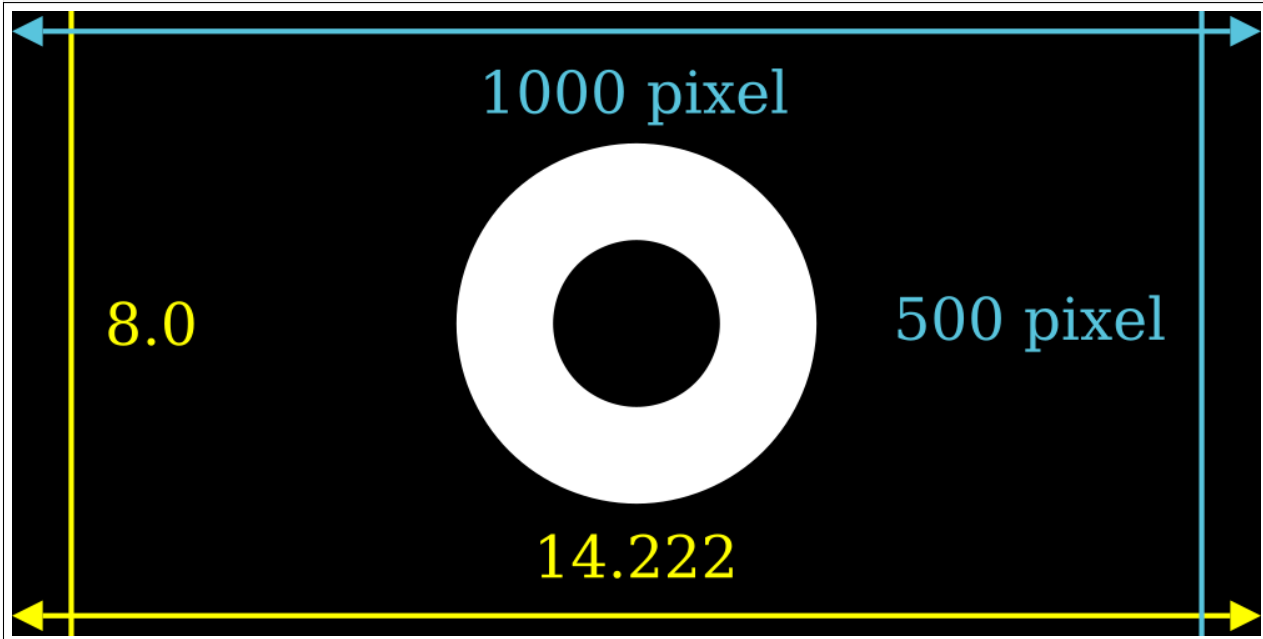
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```

↪config.pixel_width,config.pixel_height)
    self.add(frame_annotation, pixel_annotation, annulus)

```



```

[12]: %%manim -v WARNING -s -r 1000,50 --disable_caching Example
#ratio of 20/1
class Example(Scene):
    def construct(self):
        frame_annotation= yellow_frame_annotation(config.frame_width,config.frame_height)
        pixel_annotation= blue_pixel_annotation(config.frame_width,config.frame_height,
↪config.pixel_width,config.pixel_height)
        self.add(frame_annotation, pixel_annotation, annulus)

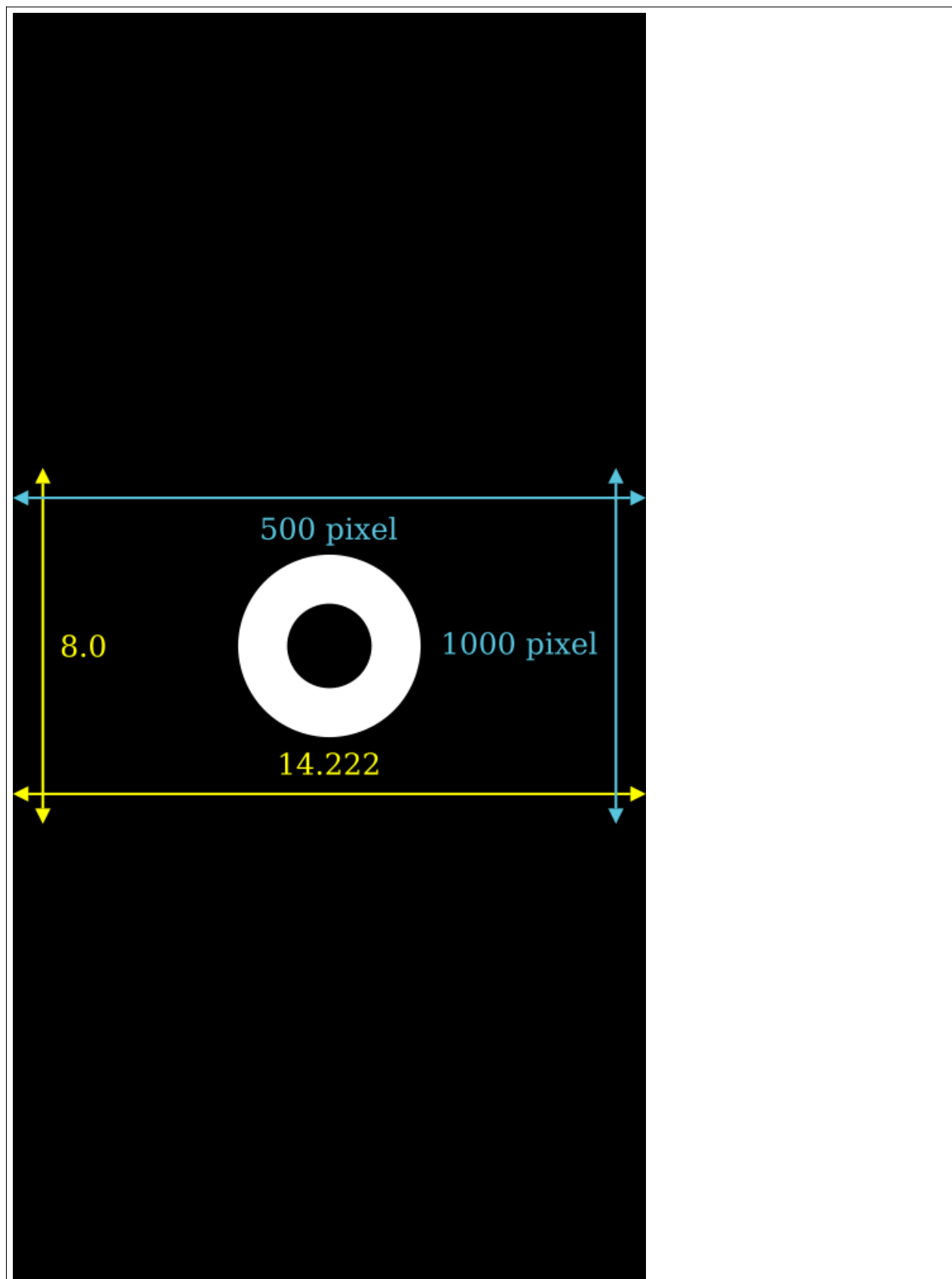
```



```

[13]: %%manim -v WARNING -s -r 500,1000 --disable_caching Example
#ratio of 1/2
class Example(Scene):
    def construct(self):
        frame_annotation= yellow_frame_annotation(config.frame_width,config.frame_height)
        pixel_annotation= blue_pixel_annotation(config.frame_width,config.frame_height,
↪config.pixel_width,config.pixel_height)
        self.add(frame_annotation, pixel_annotation, annulus)

```

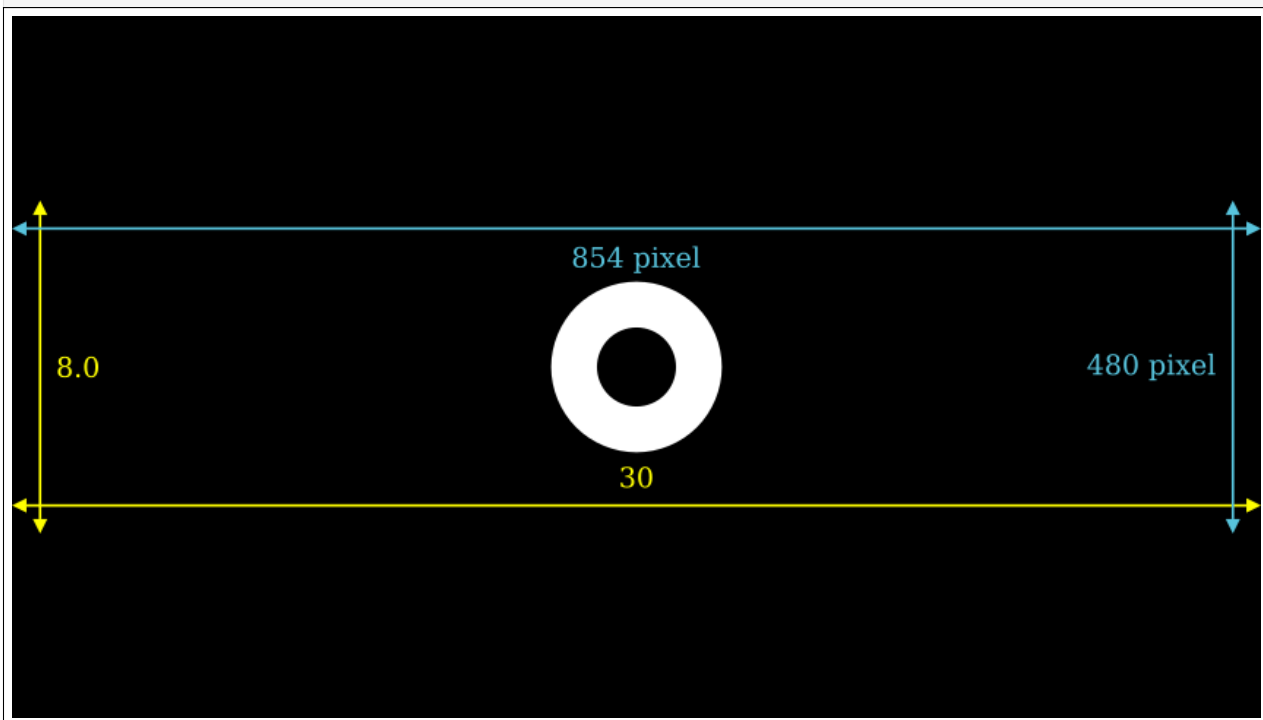


## 1.5.2 Changing the frame\_width

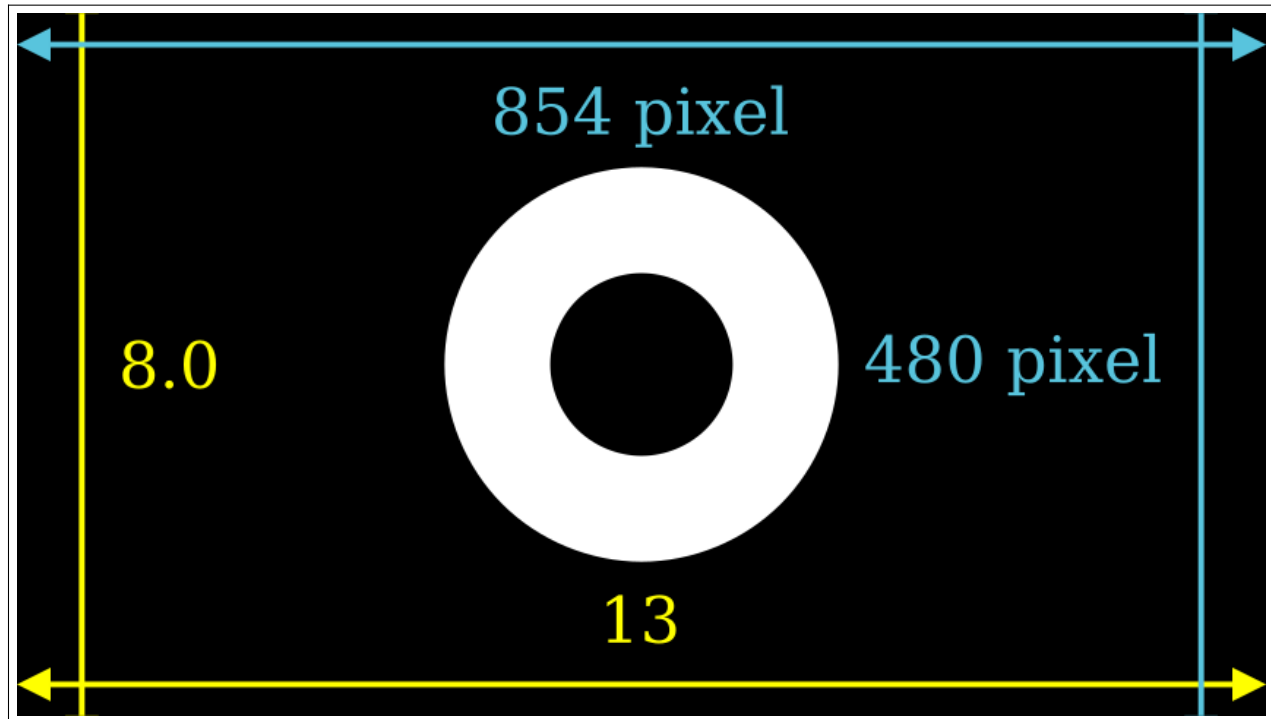
- **Increasing** the value `config.frame_width` will **zoom out** the Mobject
- **Decreasing** the value `config.frame_width` will **zoom in** the Mobject

Note: The `frame_height` is adjusted accordingly. Note 2: I do not recommend to change the frame width with `config.frame_width`, better use the `self.camera.frame.set(...)` syntax shown in the next section.

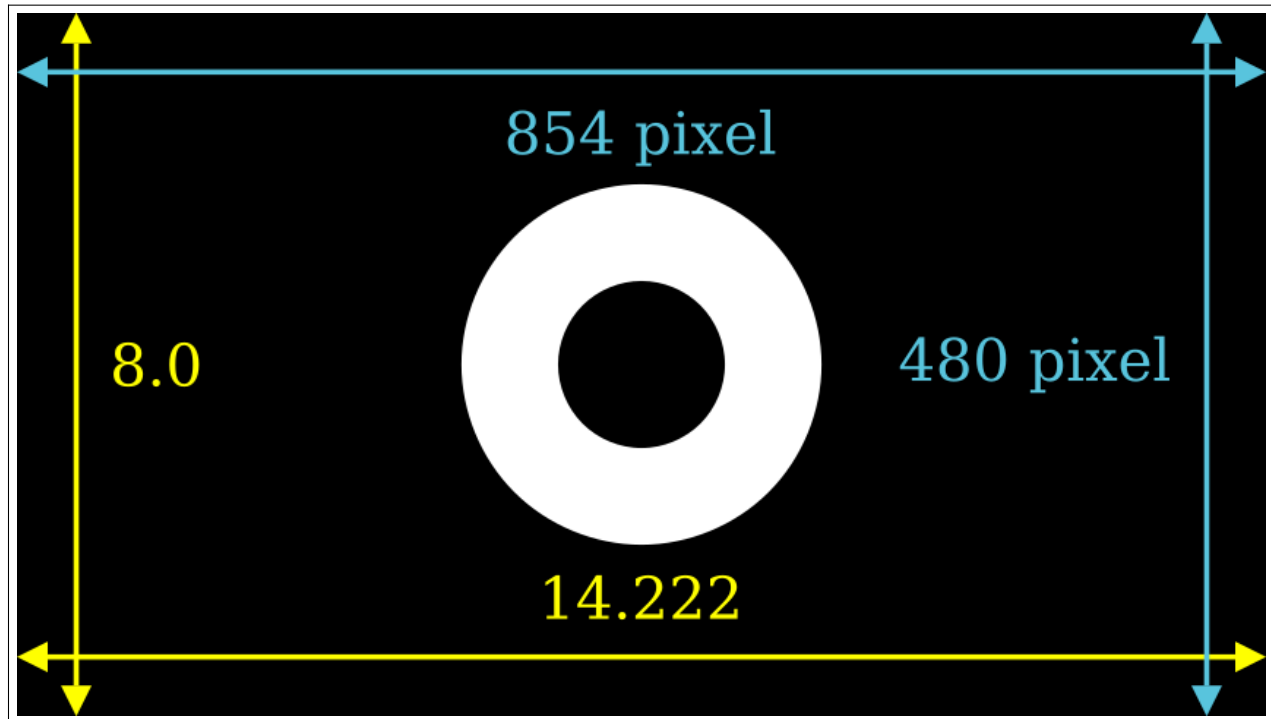
```
[14]: %%manim -v WARNING -s -ql --disable_caching Example
config.frame_width = 30
class Example(Scene):
    def construct(self):
        frame_annotation= yellow_frame_annotation(config.frame_width,config.frame_height)
        pixel_annotation= blue_pixel_annotation(config.frame_width,config.frame_height,
        ↪config.pixel_width,config.pixel_height)
        self.add(frame_annotation, pixel_annotation, annulus)
```



```
[15]: %%manim -v WARNING -s -ql --disable_caching Example
config.frame_width = 13
class Example(Scene):
    def construct(self):
        frame_annotation= yellow_frame_annotation(config.frame_width,config.frame_height)
        pixel_annotation= blue_pixel_annotation(config.frame_width,config.frame_height,
        ↪config.pixel_width,config.pixel_height)
        self.add(frame_annotation, pixel_annotation, annulus)
```



```
[16]: %%manim -v WARNING -s -ql --disable_caching Example
config.frame_width =14.22222
class Example(Scene):
    def construct(self):
        frame_annotation= yellow_frame_annotation(config.frame_width,config.frame_height)
        pixel_annotation= blue_pixel_annotation(config.frame_width,config.frame_height,
        ↪config.pixel_width,config.pixel_height)
        self.add(frame_annotation, pixel_annotation, annulus)
```



---

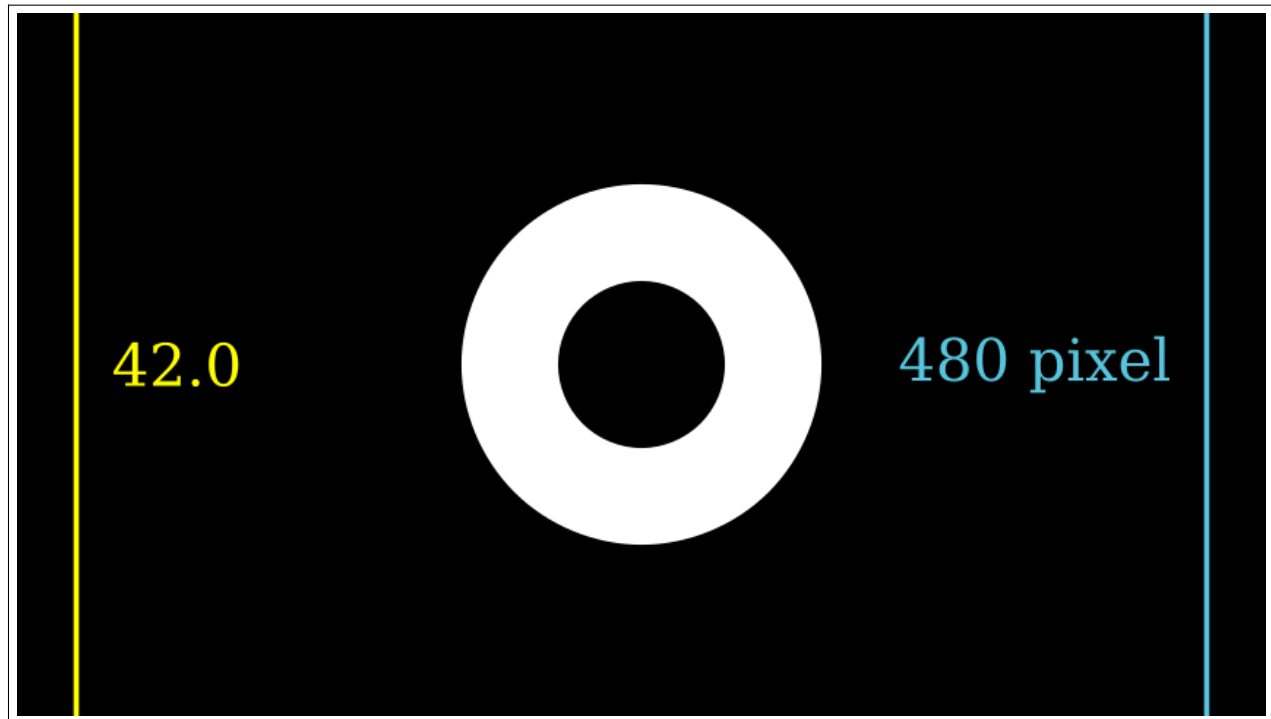
Note

Changing `config.frame_height` has no effect on the Mobjects displayed on the screen.

---

```
[17]: %%manim -v WARNING -s -ql --disable_caching Example
config.frame_height = 42
class Example(Scene):
    def construct(self):
        frame_annotation= yellow_frame_annotation(config.frame_width,config.frame_height)
        pixel_annotation= blue_pixel_annotation(config.frame_width,config.frame_height,
        ↪config.pixel_width,config.pixel_height)
        self.add(frame_annotation, pixel_annotation, annulus)
```



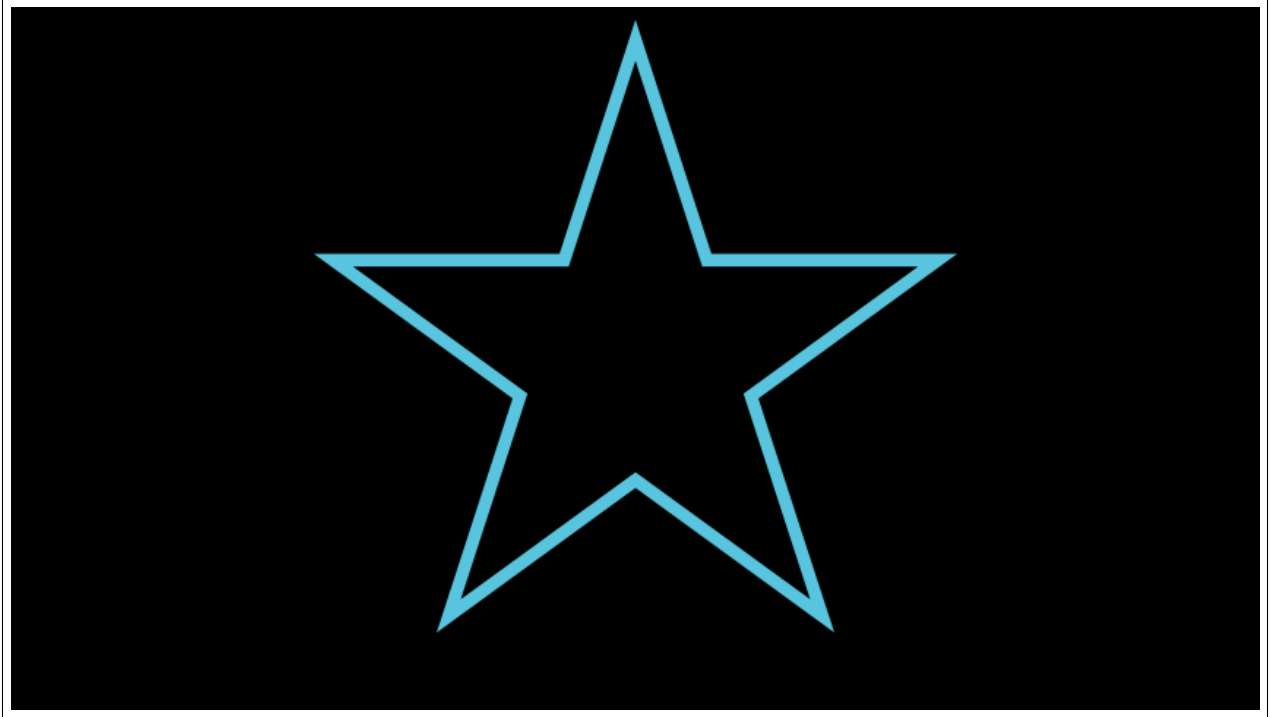


```
[18]: config.frame_height = 8 # resetting the frame_height value to default
```

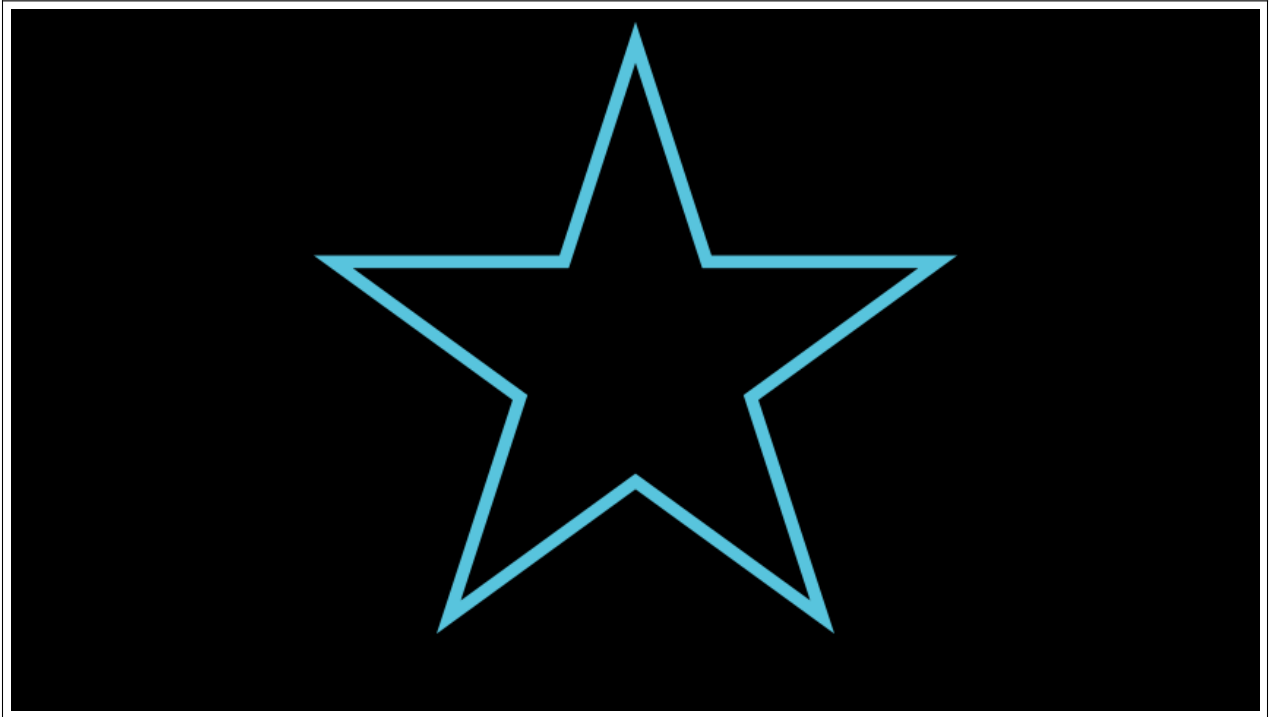
### 1.5.3 Camera Scene

```
[19]: %%manim -v WARNING -s -ql --disable_caching Example
class Example(MovingCameraScene):
    def construct(self):
        s= Star()
        self.camera.frame.set(height=s.get_height()+4*SMALL_BUFF)
        self.add(s)
```

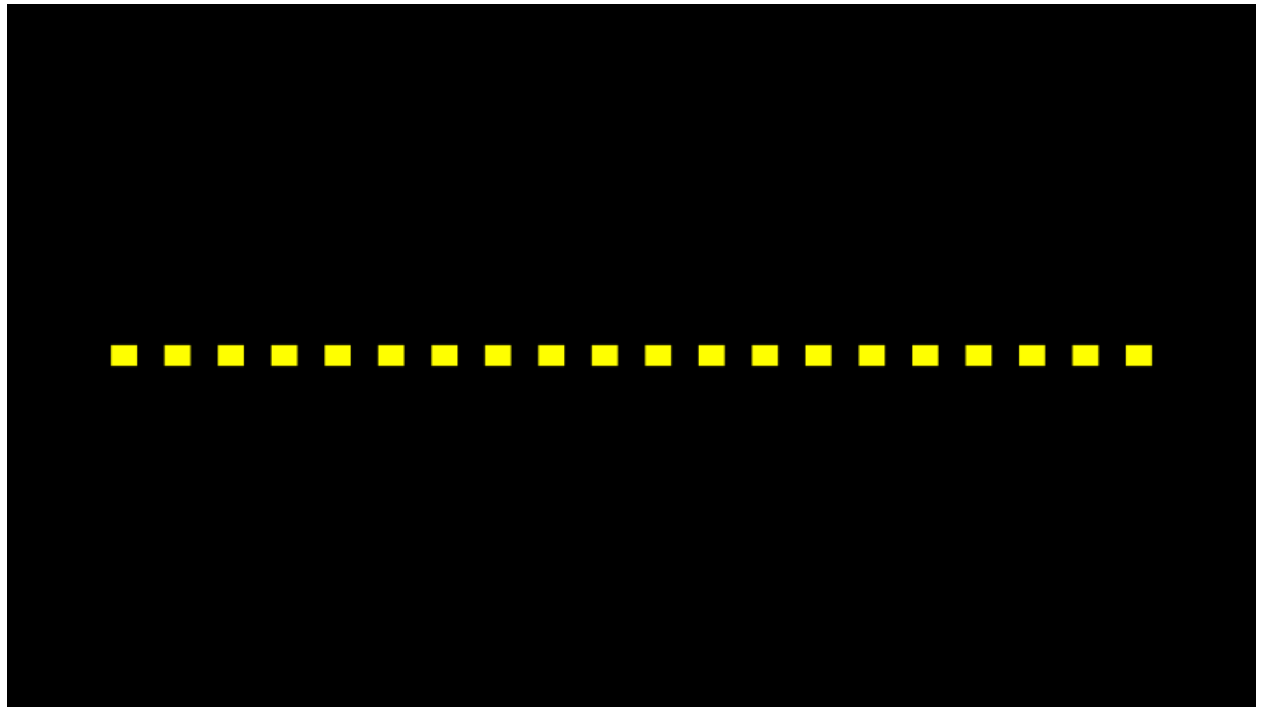
```
<string>:4: DeprecationWarning: This method is not guaranteed to stay around. Please
↳prefer getting the attribute normally.
```



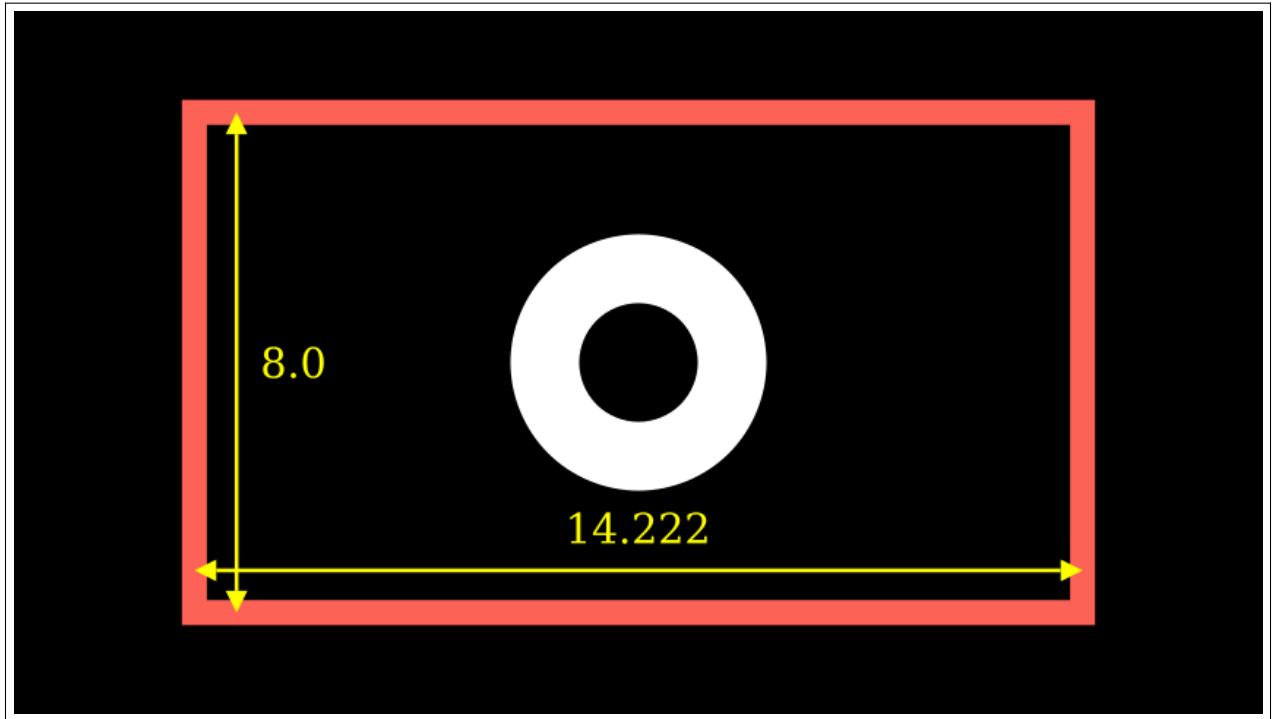
```
[20]: %%manim -v WARNING -s -ql --disable_caching Example
class Example(MovingCameraScene):
    def construct(self):
        s= Star()
        self.camera.frame.height=s.height+4*SMALL_BUFF # even better
        self.add(s)
```



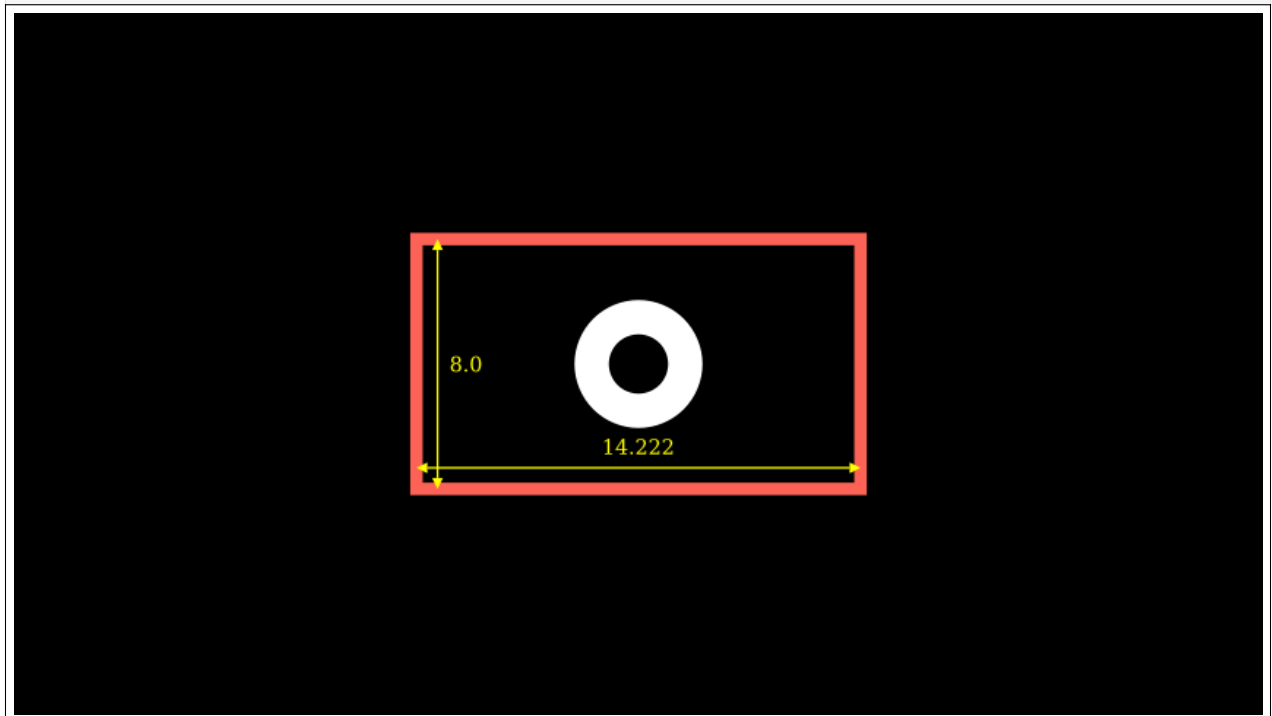
```
[21]: %%manim -v WARNING -s -ql --disable_caching Example
class Example(MovingCameraScene):
    def construct(self):
        mob = DashedLine(color= YELLOW)
        self.camera.frame.width=mob.width +4*SMALL_BUFF
        self.add(mob)
```



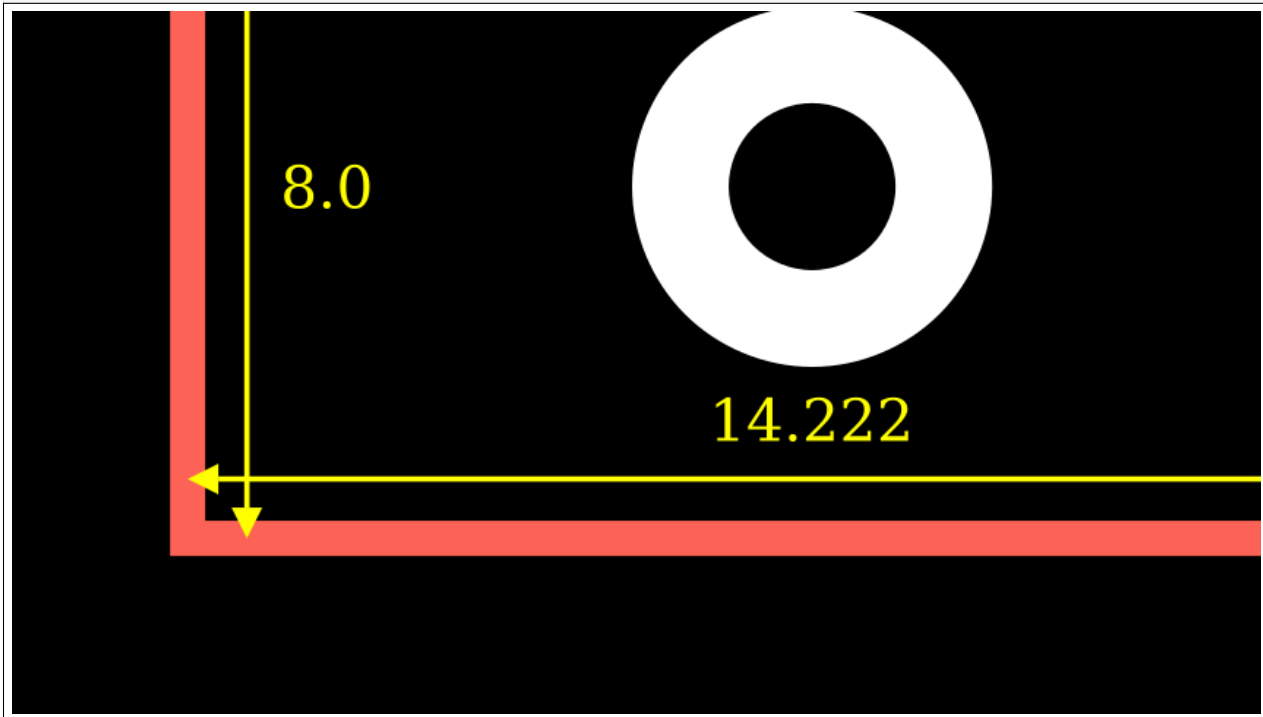
```
[22]: %%manim -v WARNING -s -ql --disable_caching Example
class Example(MovingCameraScene):
    def construct(self):
        self.camera.frame.set(width=20)
        frame_annotation= yellow_frame_annotation(config.frame_width,config.frame_height)
        self.add(FullScreenRectangle(color=RED, stroke_width=40))
        self.add(frame_annotation, annulus)
```



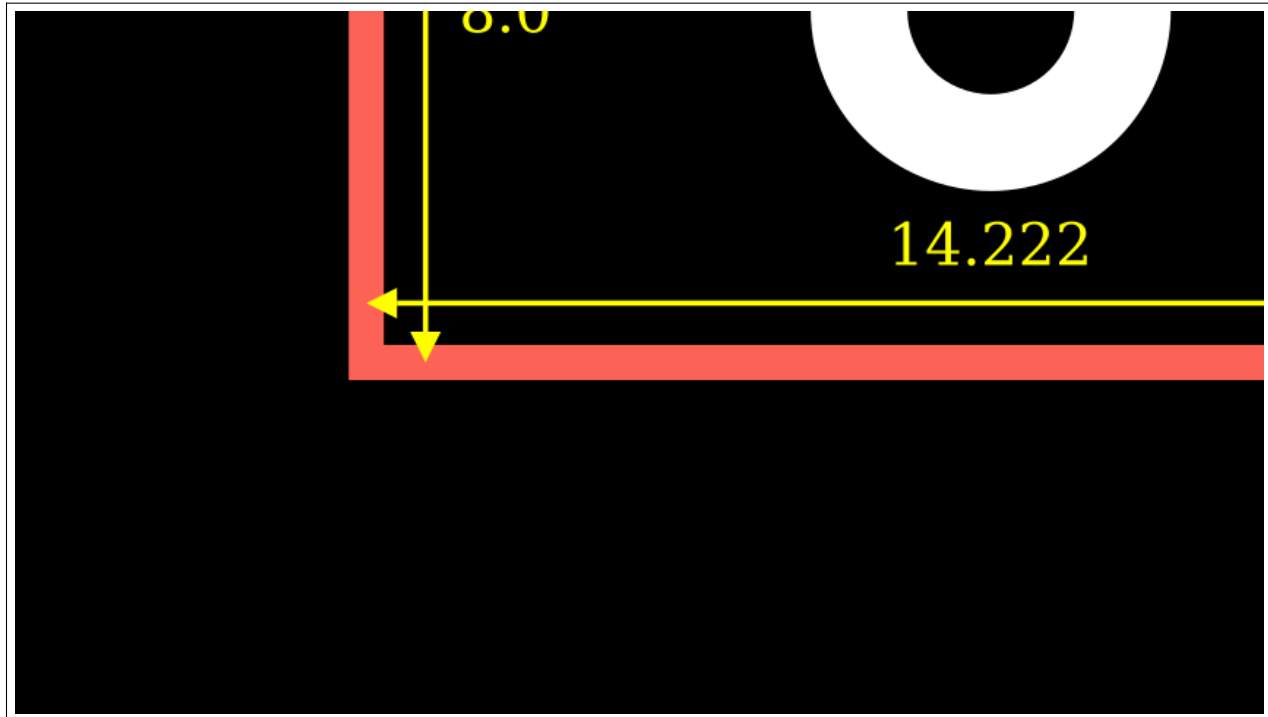
```
[23]: %%manim -v WARNING -s -ql --disable_caching Example
class Example(MovingCameraScene):
    def construct(self):
        self.camera.frame.set(width=40)
        frame_annotation= yellow_frame_annotation(config.frame_width,config.frame_height)
        self.add(FullScreenRectangle(color=RED, stroke_width=40))
        self.add(frame_annotation, annulus)
```



```
[24]: %%manim -v WARNING -s -ql --disable_caching Example
class Example(MovingCameraScene):
    def construct(self):
        self.camera.frame.shift(2*DOWN+2*LEFT)
        frame_annotation= yellow_frame_annotation(config.frame_width,config.frame_height)
        self.add(FullScreenRectangle(color=RED, stroke_width=40))
        self.add(frame_annotation, annulus)
```



```
[25]: %%manim -v WARNING -s -ql --disable_caching Example
class Example(MovingCameraScene):
    def construct(self):
        self.camera.frame.shift(4*DOWN+4*LEFT)
        frame_annotation= yellow_frame_annotation(config.frame_width,config.frame_height)
        self.add(FullScreenRectangle(color=RED, stroke_width=40))
        self.add(frame_annotation, annulus)
```



```
[26]: %%manim -v WARNING -ql --disable_caching Example
class Example(MovingCameraScene):
    def construct(self):
        frame_annotation= yellow_frame_annotation(config.frame_width,config.frame_height)
        self.add(FullScreenRectangle(color=RED, stroke_width=40))
        self.add(frame_annotation, annulus)

        self.play(self.camera.frame.animate.shift(UP+2*LEFT).set(width=20))
        self.play(self.camera.frame.animate.shift(2*DOWN+4*RIGHT))

        self.play(self.camera.frame.animate.move_to(ORIGIN).set(width=14.222))

<IPython.core.display.Video object>
```

## 1.6 Color Wheel Tutorial

In this notebook, you will learn how to create a color picker with a moving wheel in manim (scroll to the end to see the result)

```
[1]: from manim import *
config.media_embed = True
from PIL import Image
import colorsys
import math
from colorutils import hsv_to_hex,hex_to_hsv #pip install colorutils
```

Manim Community v0.17.1

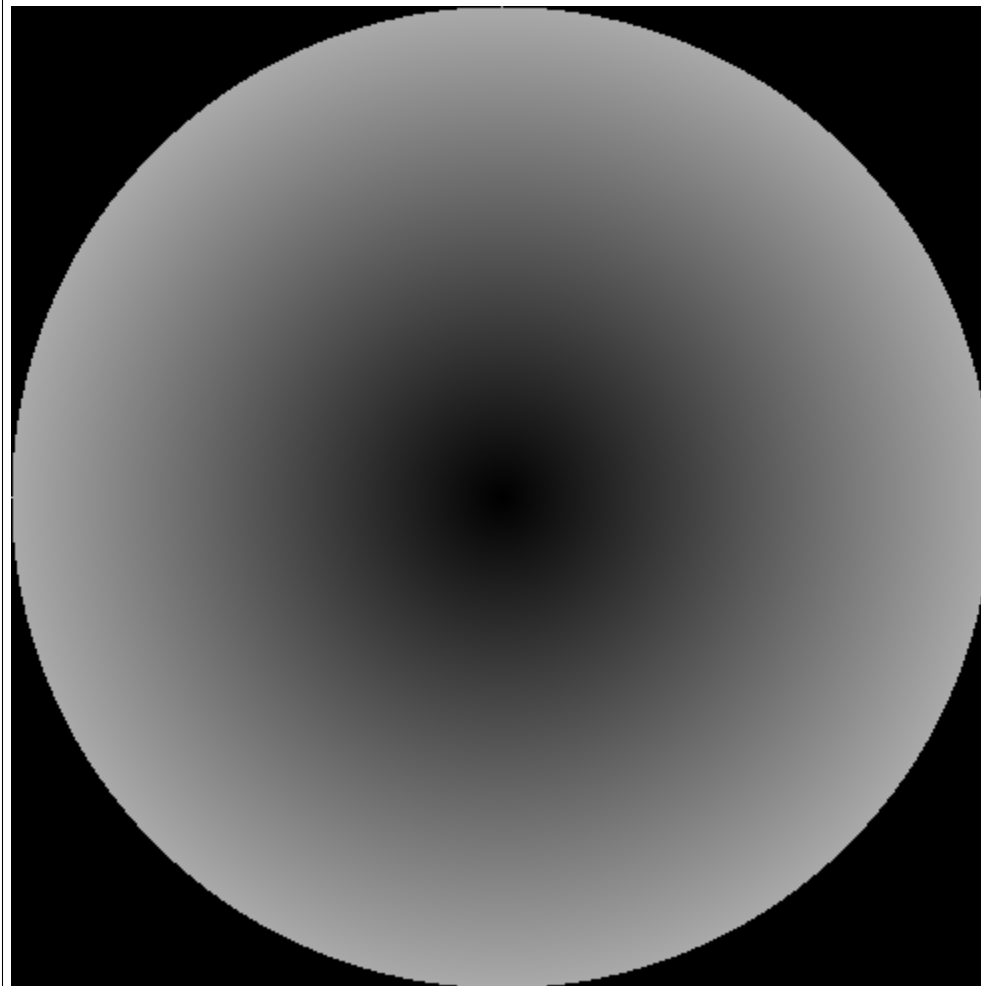
```
[2]: size=490
im = Image.new("RGB", (size,size))
radius = min(im.size)/2.0
cx, cy = im.size[0]/2, im.size[1]/2
pix = im.load()

for x in range(im.width):
    for y in range(im.height):
        rx = x - cx
        ry = y - cy
        s = (rx ** 2.0 + ry ** 2.0) ** 0.5 / radius
        if s <= 1.0:
            h = ((math.atan2(ry, rx) / math.pi) + 1.0) / 2.0
            rgb = colorsys.hsv_to_rgb(h, s, 1)
            pix[x,y] = tuple([int(round(c*255.0)) for c in rgb])
hsv_hue_sat = im
display(hsv_hue_sat)
```



```
[3]: im = Image.new("RGB", (size,size))
      radius = min(im.size)/2.0
      cx, cy = im.size[0]/2, im.size[1]/2
      pix = im.load()

      for x in range(im.width):
          for y in range(im.height):
              rx = x - cx
              ry = y - cy
              s = (rx ** 2.0 + ry ** 2.0) ** 0.5 / radius
              if s <= 1.0:
                  h = ((math.atan2(ry, rx) / math.pi) + 1.0) / 2.0
                  rgb = colorsys.hsv_to_rgb(0, s, 1 )
                  rgb = [np.mean(rgb)]*3
                  pix[x,y] = tuple([int(255-round(c*255.0)) for c in rgb])
      hsv_value = im
      display(hsv_value)
```



```
[4]: class ColorWheels(Group):
      def __init__(self, **kwargs):
          Group.__init__(self, **kwargs)
```

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```

        im_hue = ImageMobject(hsv_hue_sat).set_z_index(-5)
        im_val = ImageMobject(hsv_value).set_z_index(-5)
        # im_hue = Circle(radius=1.5).set_style(fill_color=WHITE, fill_opacity=1).set_z_
↪index(-5)
        # im_val = Circle(radius=1.5).set_style(fill_color=WHITE, fill_opacity=1).set_z_
↪index(-5)
        self.radius = im_hue.height/2
        self.add(im_hue, im_val)
        Group(*self.submobjects).arrange(DOWN, SMALL_BUFF*1.3).to_edge(RIGHT)
        t1= Text("Hue and Saturation").scale(0.3)
        t1.next_to(im_hue, UP, buff=SMALL_BUFF).rotate(35*DEGREES, about_point=im_hue.
↪get_center())
        self.add(t1)
        t2= Text("Value").scale(0.3)
        t2.next_to(im_val, UP, buff=SMALL_BUFF).rotate(35*DEGREES, about_point=im_val.
↪get_center())
        self.add(t2)
        global CENTER_HUE , CENTER_VAL
        CENTER_HUE = im_hue.get_center()
        CENTER_VAL = im_val.get_center()

```

```

[5]: class HueValSlider(Group):
    def __init__(self, wheels, h, s, v,**kwargs):
        hue_tracker= ValueTracker(h)
        sat_tracker= ValueTracker(s)
        val_tracker= ValueTracker(v)
        self.hue_tracker= hue_tracker
        self.sat_tracker= sat_tracker
        self.val_tracker= val_tracker

        Group.__init__(self, **kwargs)
        hue_dot = Dot(CENTER_HUE+LEFT).set_color(BLACK).scale(0.8).set_z_index(1)
        hue_line = Line(CENTER_HUE, hue_dot.get_center()).set_color(BLACK).set_
↪stroke(width=2)
        self.hue_line =hue_line
        hue_circ= Circle().set_color(BLACK).scale(0.08).move_to(hue_dot.get_center())
        hue_dot.add_updater(lambda x: x.move_to(CENTER_HUE+wheels.radius*sat_tracker.get_
↪value()* np.array([-np.cos(hue_tracker.get_value()*DEGREES),np.sin(hue_tracker.get_
↪value()*DEGREES),0])))
        hue_dot.add_updater(lambda x: x.set_color(hsv_to_hex((hue_tracker.get_value()
↪%360, sat_tracker.get_value(),val_tracker.get_value()))))
        hue_line.add_updater(lambda x: x.put_start_and_end_on(CENTER_HUE, hue_dot.get_
↪center()))

        hue_circ.add_updater(lambda x: x.move_to(hue_dot.get_center()))
        self.add(hue_dot, hue_circ, hue_line)

        val_dot = Dot(CENTER_VAL+LEFT).set_color(BLACK).scale(0.8).set_z_index(1)
        val_line = Line(CENTER_VAL, val_dot.get_center()).set_color(BLACK).set_
↪stroke(width=2)
        val_circ= Circle().set_color(BLACK).scale(0.08).move_to(val_dot.get_center())
        val_dot.add_updater(lambda x: x.move_to(CENTER_VAL+wheels.radius*val_tracker.get_

```

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```

↪value()* np.array([-np.cos(hue_tracker.get_value()*DEGREES),np.sin(hue_tracker.get_
↪value()*DEGREES),0])))
    val_dot.add_updater(lambda x: x.set_color(hsv_to_hex((hue_tracker.get_value()
↪%360, sat_tracker.get_value(),val_tracker.get_value()))))
    val_line.add_updater(lambda x: x.put_start_and_end_on(CENTER_VAL, val_dot.get_
↪center()))
    val_circ.add_updater(lambda x: x.move_to(val_dot.get_center()))
    self.add(val_dot, val_circ, val_line)

```

[6]: %%manim -v WARNING -qm --disable\_caching Idea3

```

class Idea3(Scene):
    def construct(self):
        wheels = ColorWheels()
        self.add(wheels)
        t1= Dot().scale(4)
        t2= Dot().scale(4)

        t3 = Dot().scale(4)
        gr = VGroup(t1,t2,t3).arrange(DOWN)
        self.add(gr)

        t1.add_updater(lambda x: x.set_color(hsv_to_hex((huevals1.hue_tracker.get_value()
↪%360, huevals1.sat_tracker.get_value(),1))))
        t2.add_updater(lambda x: x.set_color(hsv_to_hex((huevals2.hue_tracker.get_value()
↪%360, huevals2.sat_tracker.get_value(),1))))
        t3.add_updater(lambda x: x.set_color(hsv_to_hex((huevals3.hue_tracker.get_value()
↪%360, huevals3.sat_tracker.get_value(),1))))

        huevals1=HueValSlider(wheels,0,1,1)
        huevals2=HueValSlider(wheels,120,1,1)
        huevals3=HueValSlider(wheels,240,1,1)

        self.add(huevals1)
        self.add(huevals2)
        self.add(huevals3)
        hues_all_tracker = ValueTracker(0)

        self.add(hues_all_tracker)
        self.add(huevals1.hue_tracker)
        self.add(huevals2.hue_tracker)
        self.add(huevals3.hue_tracker)

        huevals1.hue_tracker.add_updater(lambda mobject, dt: mobject.increment_
↪value(dt*30))
        huevals2.hue_tracker.add_updater(lambda mobject, dt: mobject.increment_
↪value(dt*30))
        huevals3.hue_tracker.add_updater(lambda mobject, dt: mobject.increment_
↪value(dt*30))

```

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```

self.wait(3)

self.play(
    huevals1.sat_tracker.animate.increment_value(-0.2),
    huevals2.sat_tracker.animate.increment_value(-0.2),
    huevals3.sat_tracker.animate.increment_value(-0.2),
)
self.wait(1)
self.play(
    huevals1.val_tracker.animate.increment_value(-0.2),
    huevals2.val_tracker.animate.increment_value(-0.2),
    huevals3.val_tracker.animate.increment_value(-0.2),
)
self.wait(1)

```

```
<IPython.core.display.Video object>
```

[ ]:

## 1.7 Scene Building With Plots

One can distinguish between two kinds of plots:

- Quantitative scientific plots with numbers and dimensions to describe data (e.g. made with matplotlib).
- Qualitative explanatory plots that convey a message in the clearest way possible (e.g. made with manim)

In this tutorial, I will take you on a journey from choosing a topic to making a scientific plot to then transforming it into an explanatory plot with manim:

### 1.7.1 Formulating a Quantitative Concept

First, we do research on our topic of choice and then look up the formulas that we need. Alternatively, one can search for existing implementations.

I chose the carnot process where I want to see how the pressure **pressure p** is altering, when **volume V** or **temperature T** are changing.

In order to see how this works, the only think we need to know is that the Carnot Cycle obeys these formulas:

- $pV = RT$  \$ ideal gas equation
- $pV = \text{const}$  \$ upper and lower curve (also called “isotherm”)
- $pV^k = \text{const}$  \$ with  $k = 5/3$  \$ for the left and right curve (also called “adiabatic”)

You don’t have to understand these formulas in detail in order to understand this tutorial.

As we need reference points in the diagram, we first define some default values.

For temperatures, we choose  $20^\circ\text{C}$  and  $300^\circ\text{C}$ . For volumes we choose  $v_1 = 1\text{ m}^3$ , and  $v_2 = 2\text{ m}^3$ .

```
[1]: import numpy as np
import matplotlib.pyplot as plt
from scipy.constants import zero_Celsius
plt.rcParams['figure.dpi'] = 150

Tmax = zero_Celsius + 300
Tmin = zero_Celsius + 20
R = 8.314
kappa = 5/3
V1= 1
V2= 2
```

Now, let's have a look on the plot via matplotlib. As of now, implementing and debugging formulas is important, design is not.

```
[2]: p1 = R*Tmax/V1 # ideal gas equation
p2 = p1*V1/V2

V3 = (Tmax/Tmin * V2**(kappa-1))**(1/(kappa-1))
p3 = p2* V2**kappa / V3**kappa

V4 = (Tmax/Tmin * V1**(kappa-1))**(1/(kappa-1))
p4 = p3*V3/V4

V12 = np.linspace(V1,V2,100)
V23 = np.linspace(V2,V3,100)
V34 = np.linspace(V3,V4,100)
V41 = np.linspace(V4,V1,100)

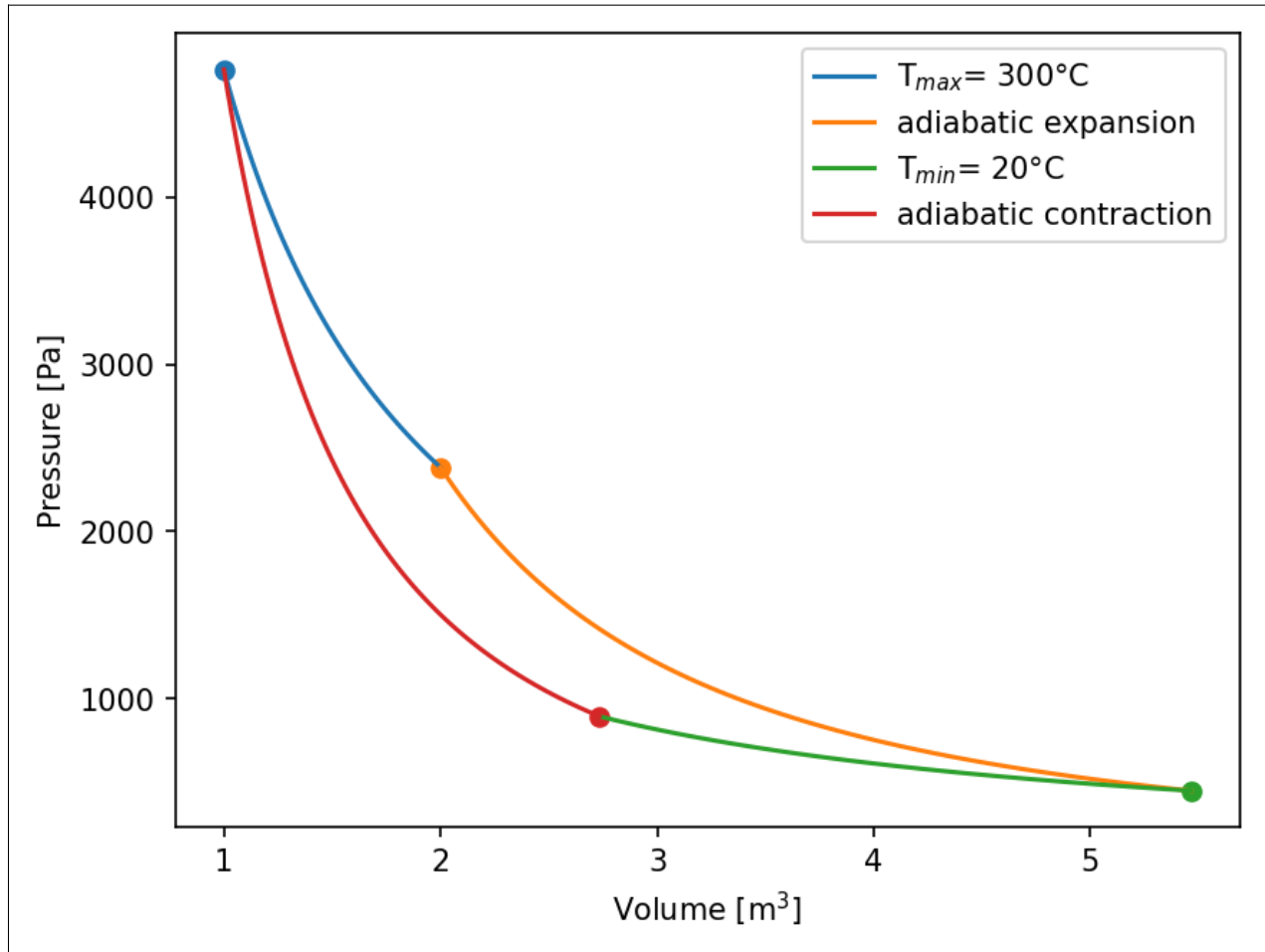
def p_isotherm(V,T):
    return (R*T)/V

def p_adiabatisch(V,p_start,v_start):
    return (p_start*v_start**kappa)/V**kappa

plt.plot(V12, p_isotherm(V12,Tmax),label = "T$_{max}$" +f"= {Tmax-zero_Celsius:.0f}$^\circ\text{C}$")
plt.plot(V23, p_adiabatisch(V23, p2,V2),label = f"adiabatic expansion")
plt.plot(V34, p_isotherm(V34,Tmin),label = "T$_{min}$" +f"= {Tmin-zero_Celsius:.0f}$^\circ\text{C}$")
plt.plot(V41, p_adiabatisch(V41, p4,V4),label = f"adiabatic contraction")

plt.legend()
plt.scatter(V1,p1)
plt.scatter(V2,p2)
plt.scatter(V3,p3)
plt.scatter(V4,p4)

plt.ylabel("Pressure [Pa]")
plt.xlabel("Volume [m$^3$]")
plt.ticklabel_format(axis="x", style="sci", scilimits=(0,5))
```



Good! Now comes the second part:  
Building the explanatory plot!

## 1.7.2 Extending to The Qualitative Concept

Now we have a good basis to convert this idea into a visually appealing and explanatory graph that will make it easy for everyone to understand complex problems.

```
[3]: from manim import *
      config.media_embed = True
      param = "-v WARNING -s -ql --disable_caching --progress_bar None Example"

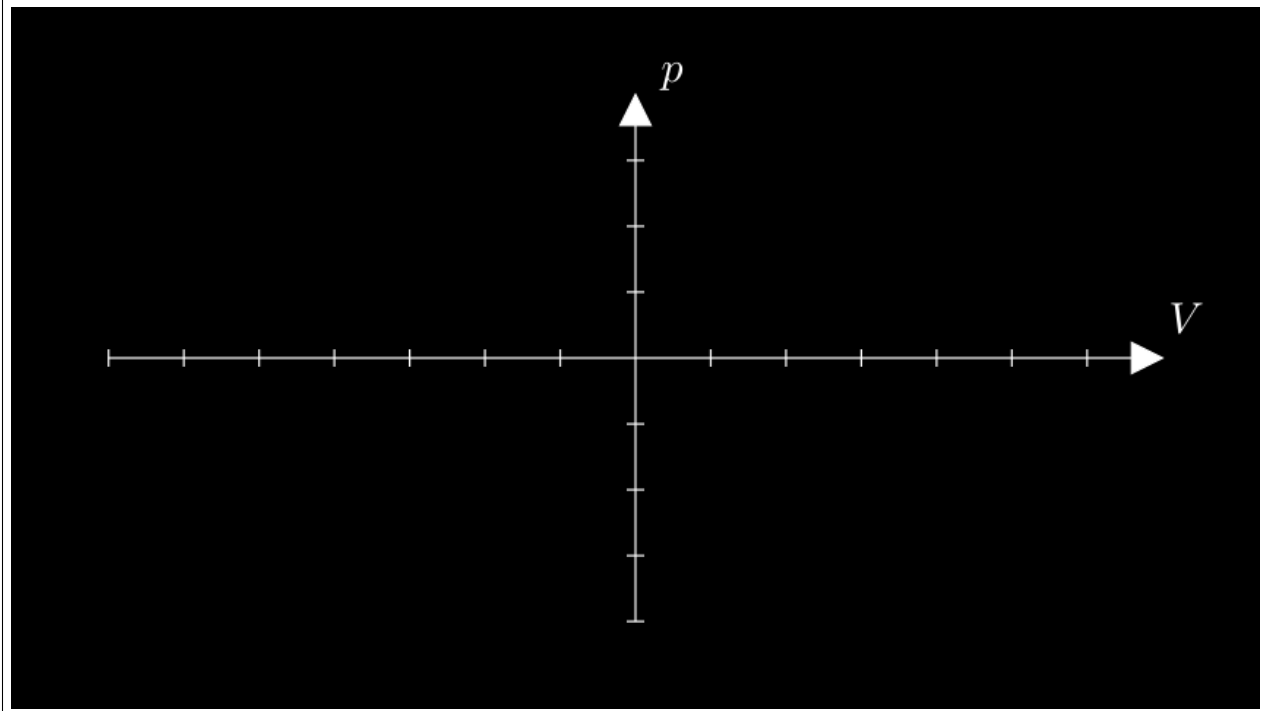
      Manim Community v0.17.1
```

```
[4]: %%manim $param
      class Example(Scene):
          def construct(self):
              my_ax = Axes()
```

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```
labels = my_ax.get_axis_labels(x_label="V", y_label="p")
self.add(my_ax, labels)
```



```
[5]: # making some styling here
Axes.set_default(axis_config={"color": BLACK}, tips= False)
MathTex.set_default(color = BLACK)
config.background_color = WHITE
```

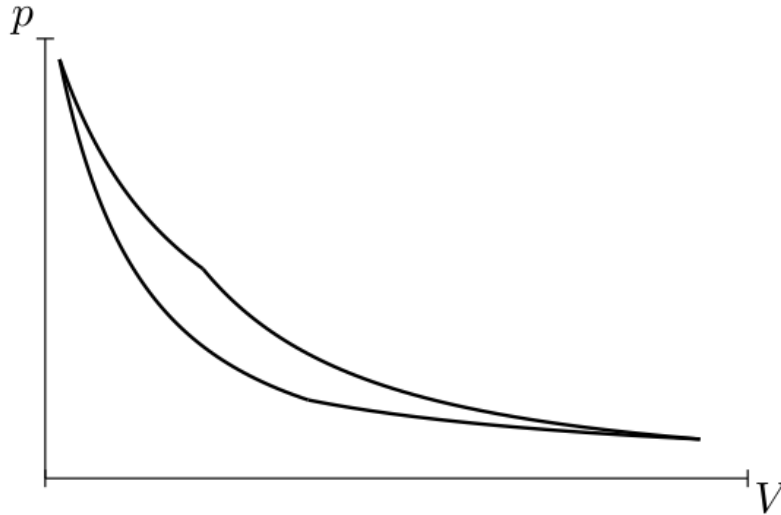
```
[6]: %%manim $param
ax = Axes(x_range=[0.9, 5.8, 4.9], y_range=[0, 5000, 5000], x_length=8, y_length=5, stroke_
↪color=BLACK)
labels = ax.get_axis_labels(x_label="V", y_label="p")
labels[0].shift(.6*DOWN)
labels[1].shift(.6*LEFT)
isotherm12_graph = ax.plot(
    lambda x: p_isotherm(x, Tmax), x_range=[V1, V2, 0.01], color=BLACK
)
adiabatisch23_graph = ax.plot(
    lambda x: p_adiabatisch(x, p2, V2) , x_range=[V2, V3, 0.01], color=BLACK
)
isotherm34_graph = ax.plot(
    lambda x: p_isotherm(x, Tmin), x_range=[V3, V4, -0.01], color=BLACK
)
adiabatisch41_graph = ax.plot(
    lambda x: p_adiabatisch(x, p4, V4), x_range=[V4, V1, -0.01], color=BLACK
)
lines = VGroup(
    isotherm12_graph, adiabatisch23_graph, isotherm34_graph, adiabatisch41_graph
)
```

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```
ax.add(labels)

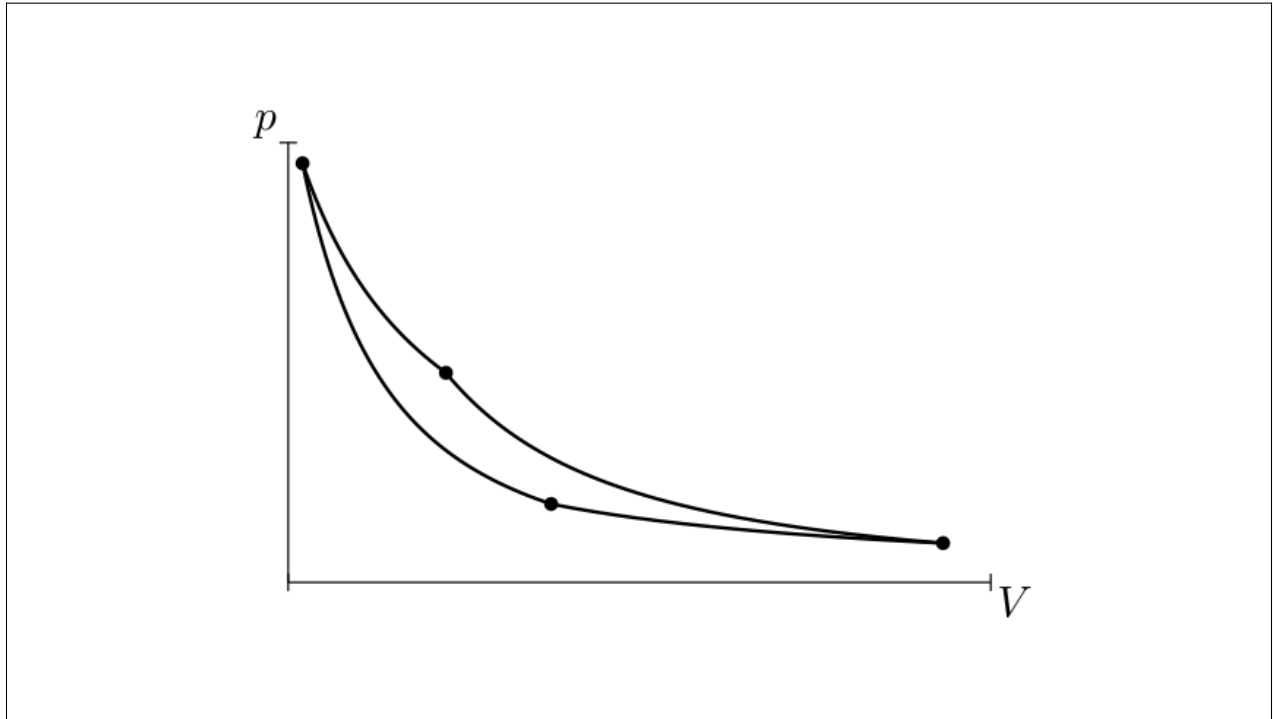
class Example(Scene):
    def construct(self):
        self.add(ax, lines)
```



```
[7]: %%manim $param

Dot.set_default(color=BLACK)
dots = VGroup()
dots += Dot().move_to(isotherm12_graph.get_start())
dots += Dot().move_to(isotherm12_graph.get_end())
dots += Dot().move_to(isotherm34_graph.get_start())
dots += Dot().move_to(isotherm34_graph.get_end())

class Example(Scene):
    def construct(self):
        self.add(ax, lines, dots)
```

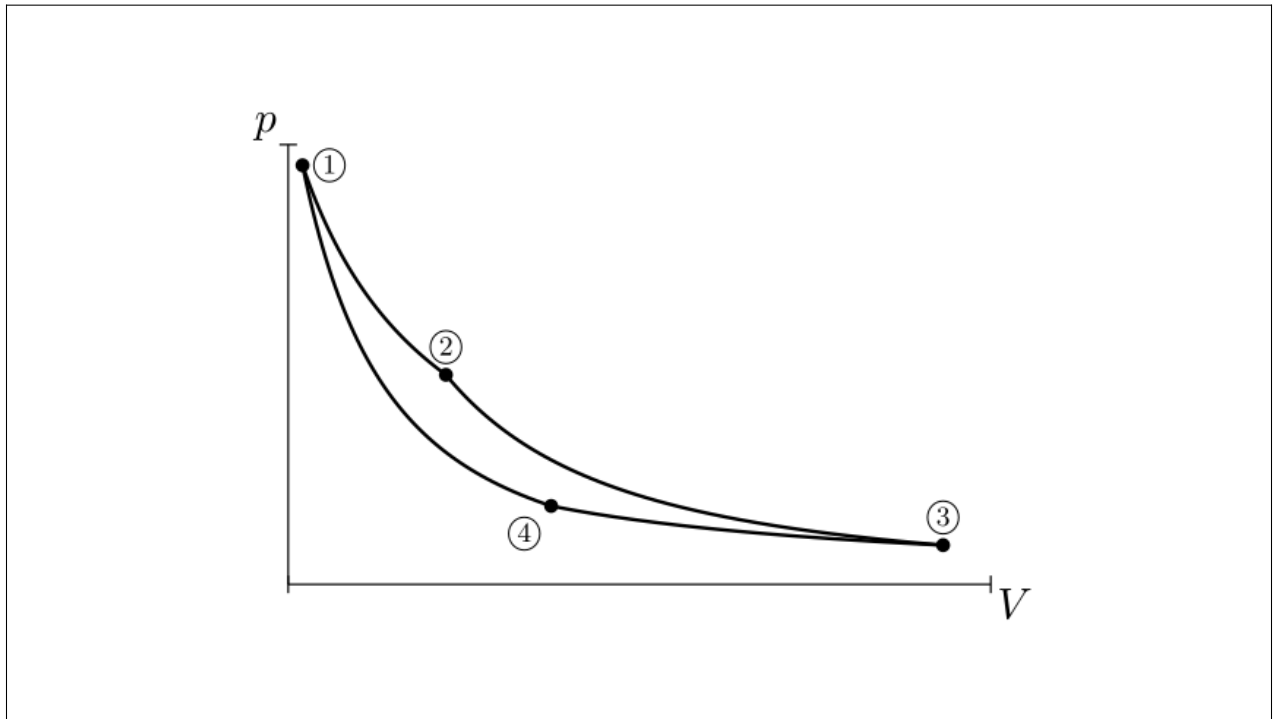


```
[8]: %%manim $param

nums= VGroup()
nums+= MathTex(r"\large \textcircled{\small 1} ").scale(0.7).next_to(dots[0],RIGHT,
↪buff=0.4*SMALL_BUFF)
nums+= MathTex(r"\large \textcircled{\small 2} ").scale(0.7).next_to(dots[1],UP,↪
↪buff=0.4 * SMALL_BUFF)
nums+= MathTex(r"\large \textcircled{\small 3} ").scale(0.7).next_to(dots[2],UP,buff=0.
↪4*SMALL_BUFF)
nums+= MathTex(r"\large \textcircled{\small 4} ").scale(0.7).next_to(dots[3],DL ,
↪buff=0.4*SMALL_BUFF)

class Example(Scene):
    def construct(self):
        self.add(ax,lines, dots,nums)
```

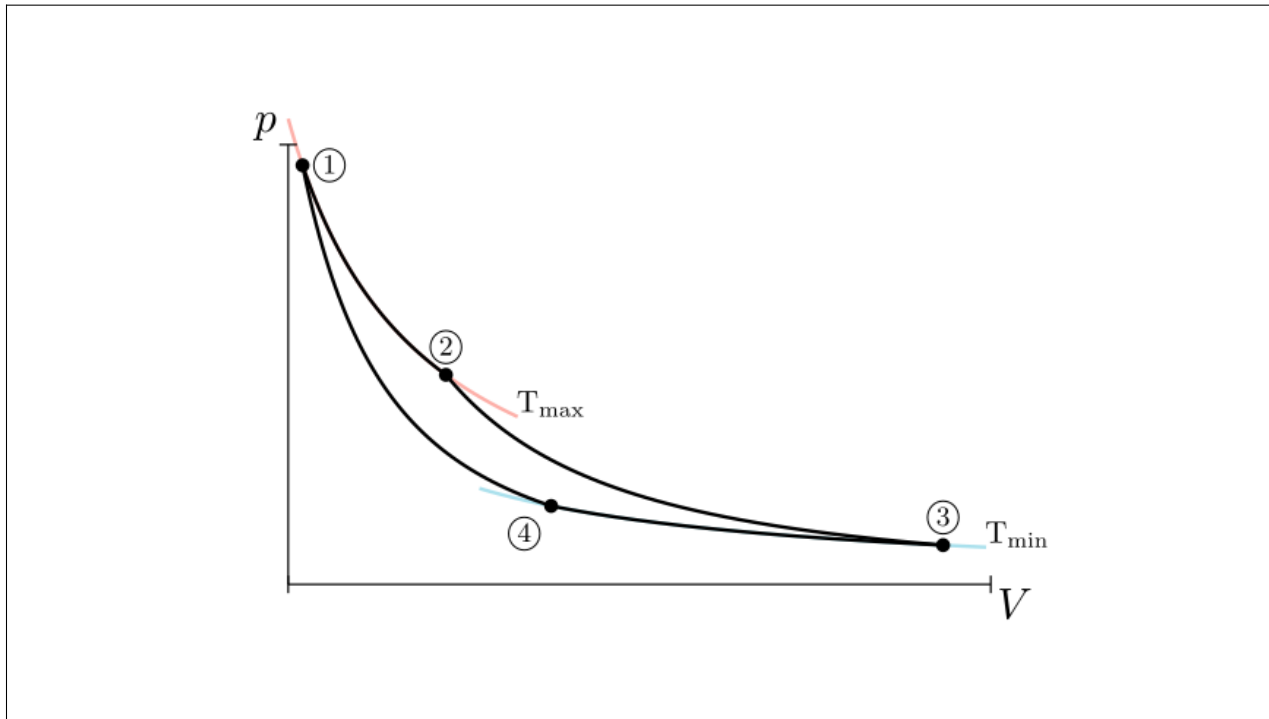




```
[9]: %%manim $param

background_strokes = VGroup()
background_strokes += ax.plot(lambda x: p_isotherm(x, Tmax), x_range=[V1 - 0.1, V2 + 0.5, ↵
↵0.01], color=RED, stroke_opacity=0.5)
background_strokes += ax.plot(lambda x: p_isotherm(x, Tmin), x_range=[V3 + 0.3, V4 - 0.5, ↵
↵0.01], color=BLUE, stroke_opacity=0.5)
background_strokes.set_z_index(-1);
label = VGroup()
label += MathTex(r"\text{T}_{\text{min}}").scale(0.7).next_to(background_strokes[1],
↵RIGHT, aligned_edge=DOWN, buff=0)
label += MathTex(r"\text{T}_{\text{max}}").scale(0.7).next_to(background_strokes[0],
↵RIGHT, aligned_edge=DOWN, buff=0)
background_strokes += label

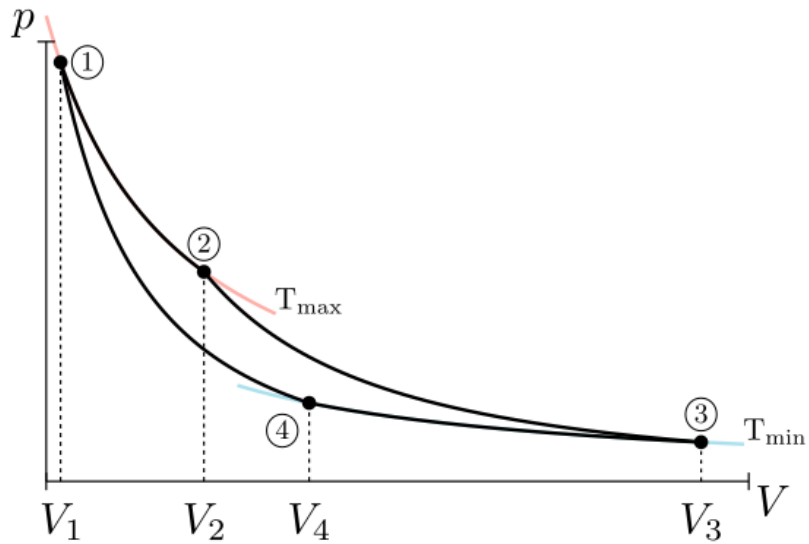
class Example(Scene):
    def construct(self):
        self.add(ax, lines, dots, nums, background_strokes)
```



```
[10]: %%manim $param

downstrokes = VGroup()
downstrokes += ax.get_vertical_line(ax.i2gp(V1, isotherm12_graph), color=BLACK).set_z_
↳index(-2)
downstrokes += ax.get_vertical_line(ax.i2gp(V2, isotherm12_graph), color=BLACK).set_z_
↳index(-2)
downstrokes += ax.get_vertical_line(ax.i2gp(V3, isotherm34_graph), color=BLACK).set_z_
↳index(-2)
downstrokes += ax.get_vertical_line(ax.i2gp(V4, isotherm34_graph), color=BLACK).set_z_
↳index(-2)
down_labels= VGroup()
down_labels += MathTex("{ V }_{ 1 }").next_to(downstrokes[0], DOWN)
down_labels += MathTex("{ V }_{ 2 }").next_to(downstrokes[1], DOWN)
down_labels += MathTex("{ V }_{ 3 }").next_to(downstrokes[2], DOWN)
down_labels += MathTex("{ V }_{ 4 }").next_to(downstrokes[3], DOWN)

class Example(Scene):
    def construct(self):
        self.add(ax, lines, dots, nums, background_strokes, downstrokes, down_labels)
```



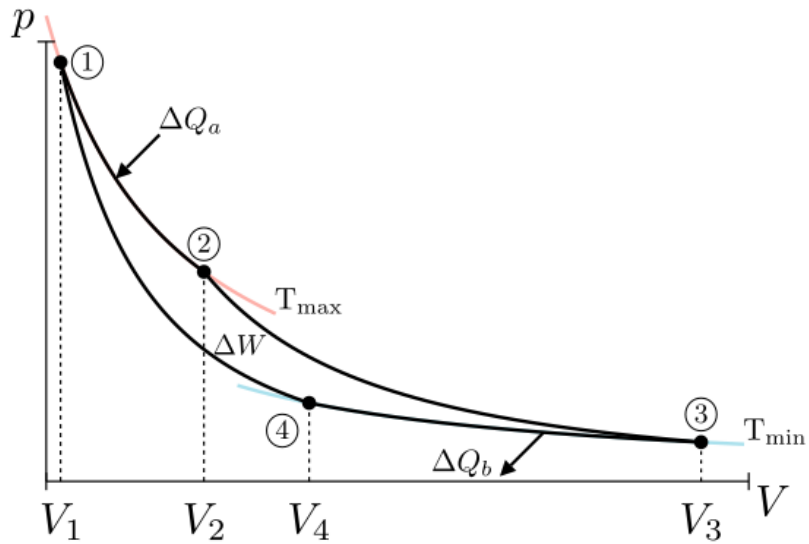
```
[11]: %%manim $param

heat_annotation = VGroup()
deltaW = MathTex(r"\Delta W").next_to(dots[3], UL).scale(0.65).shift(0.15 * UP)
bg = deltaW.add_background_rectangle(color=WHITE)
heat_annotation += deltaW

point = isotherm12_graph.point_from_proportion(0.5)
arrow = Arrow(point + UR * 0.5, point, buff=0).set_color(BLACK)
deltaQa = MathTex(r"\Delta Q_a").scale(0.7).next_to(arrow, UR, buff=0)
heat_annotation += arrow
heat_annotation += deltaQa

point = isotherm34_graph.point_from_proportion(0.4)
arrow = Arrow(point, point + DL * 0.5, buff=0).set_color(BLACK)
deltaQb = MathTex(r"\Delta Q_b").scale(0.7).next_to(arrow, LEFT, buff=0.1).shift(0.1 *
↳DOWN)
heat_annotation += arrow
heat_annotation += deltaQb

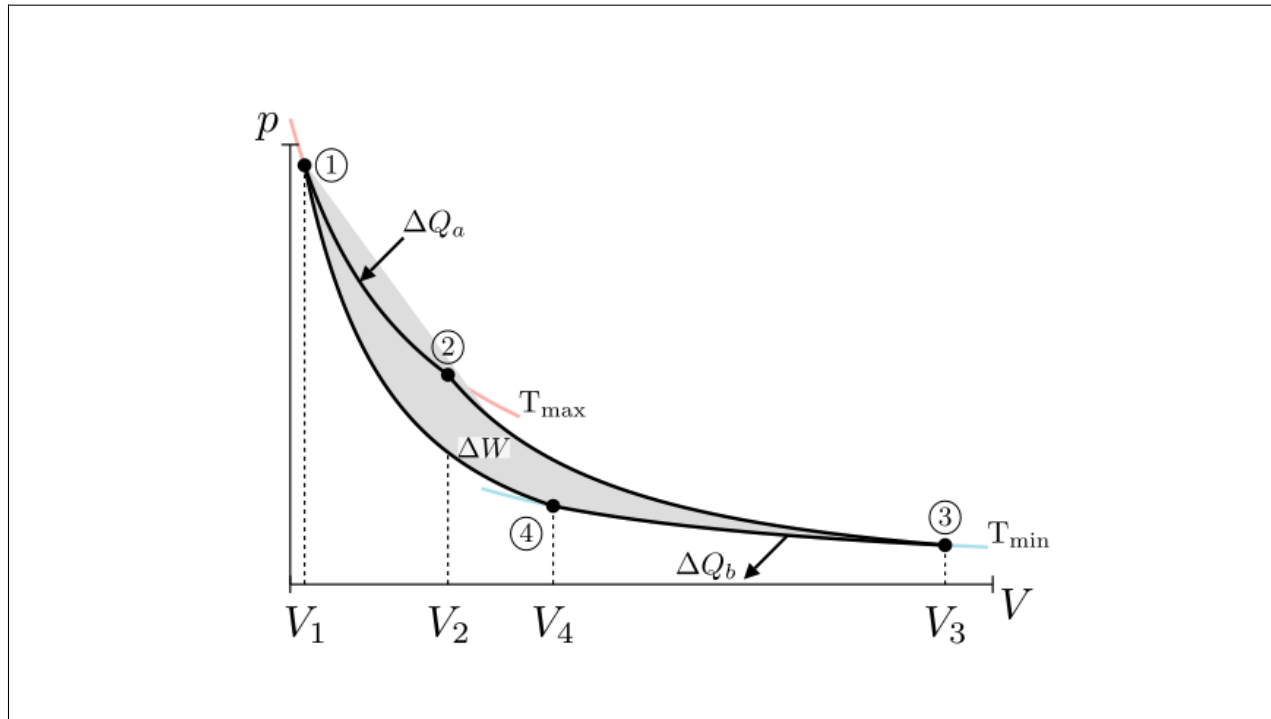
class Example(Scene):
    def construct(self):
        self.add(ax, lines, dots, nums, background_strokes, downstrokes, down_labels, heat_
↳annotation)
```



```
[12]: %%manim $param

c1 = Cutout(lines[0].copy().reverse_points(),lines[3]).set_opacity(1).set_color(GREEN)
c2 = Cutout(lines[1],lines[2])
bg_grey = Union(c1,c2, color=GREY_A).set_opacity(1)
bg_grey.z_index=-1

class Example(Scene):
    def construct(self):
        #self.add(c1,c2)
        self.add(ax,lines, dots,nums,background_strokes)
        self.add(downstrokes,down_labels,heat_annotation,bg_grey)
```



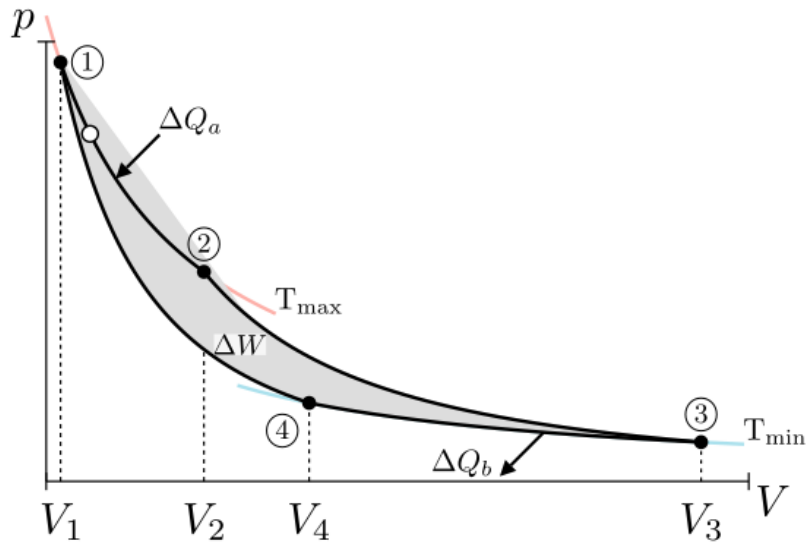
```
[13]: carnot_graph= VGroup(ax,lines, dots,nums,background_strokes,downstrokes,down_labels,heat_
      ↪annotation,bg_grey)
```

And here is the final plot:

```
[14]: %%manim $param

sourunding_dot = Dot().scale(1.3).set_fill(color=BLACK).set_z_index(-1)
innerdot = Dot().set_color(WHITE).scale(1)
moving_dot = VGroup(sourunding_dot, innerdot)
moving_dot.move_to(isotherm12_graph.point_from_proportion(0.3))

class Example(Scene):
    def construct(self):
        self.add(carnot_graph)
        self.add(moving_dot)
```

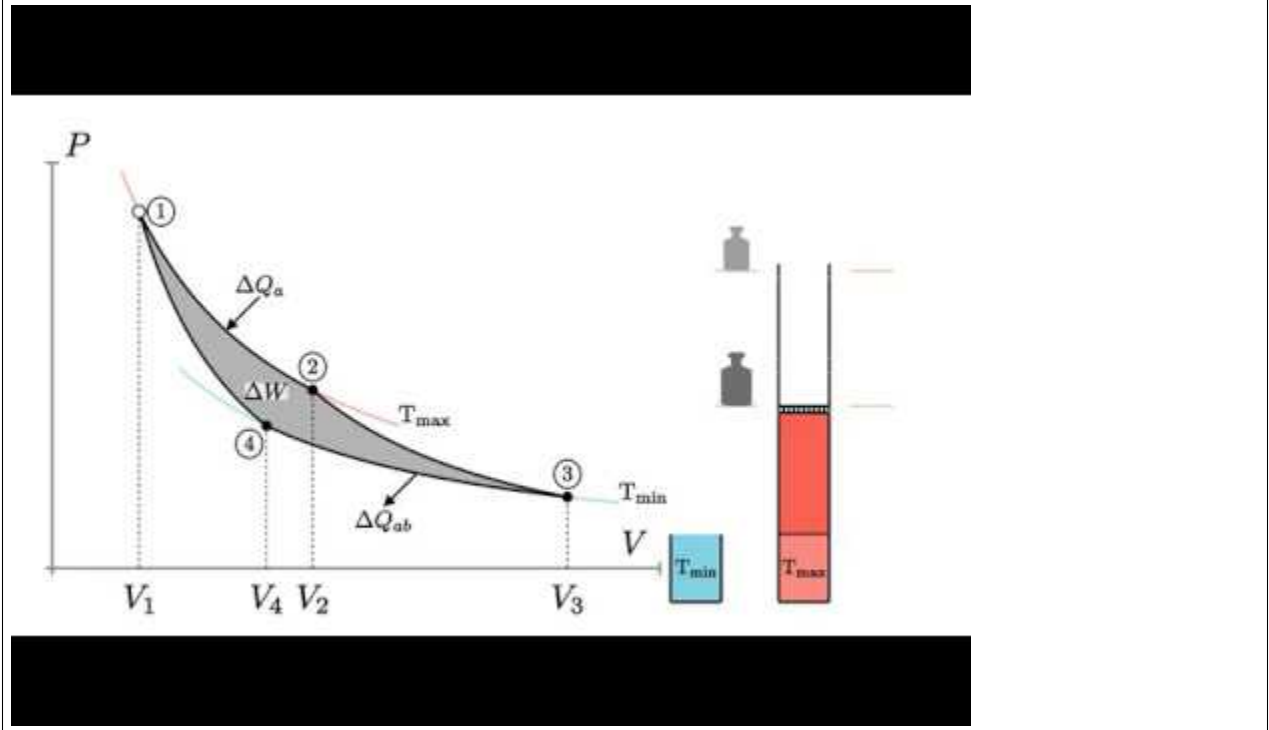


### 1.7.3 Outlook

After having this foundation of an explanatory plot, one can go on and animate it as can be seen here.  
(A tutorial for this animation will follow!)

```
[15]: from IPython.display import YouTubeVideo
      YouTubeVideo('_8RkZaiXP0E', width=800, height=600)
```

[15]:



[ ]:

## 1.8 Advanced

### 1.8.1 Matplotlib and manim combined

```
[1]: from manim import *
      config.media_embed = True

      import matplotlib.pyplot as plt

      param = "-v WARNING -s -ql --disable_caching --progress_bar None Example"
      paramH = "-v WARNING -s -qh --disable_caching --progress_bar None Example"
      paramamp = "-v WARNING -ql --disable_caching --progress_bar None Example"
      paramampH = "-v WARNING -qh --disable_caching --progress_bar None Example"

      Manim Community v0.17.1
```

```
[2]: %%manim $paramamp

      plt.rcParams['figure.dpi'] = 100

      def my_function(amplitude, x):
          return amplitude * np.sin(x)
```

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```

def mpl_image_plt(amplitude, x):
    fig, ax = plt.subplots()
    ax.plot(x, my_function(amplitude, x))
    ax.set_ylim(-1, 1)
    fig.canvas.draw()
    img = ImageMobject(fig.canvas.buffer_rgba()).scale(2)
    plt.close(fig)
    return img

class Example(Scene):
    def construct(self):
        self.camera.background_color=WHITE
        x_values = np.linspace(0, 30, 400)
        amp1 = 0.5
        amp2 = 1
        tr_amplitude = ValueTracker(amp1)
        image = mpl_image_plt(amp1, x_values)
        self.add(image)

        def update_image(mob):
            new_mob = mpl_image_plt(tr_amplitude.get_value(), x_values)
            mob.become(new_mob)

        image.add_updater(update_image)
        self.play(tr_amplitude.animate.set_value(amp2), run_time=3)

```

<IPython.core.display.Video object>

[3]: %%manim \$paramp

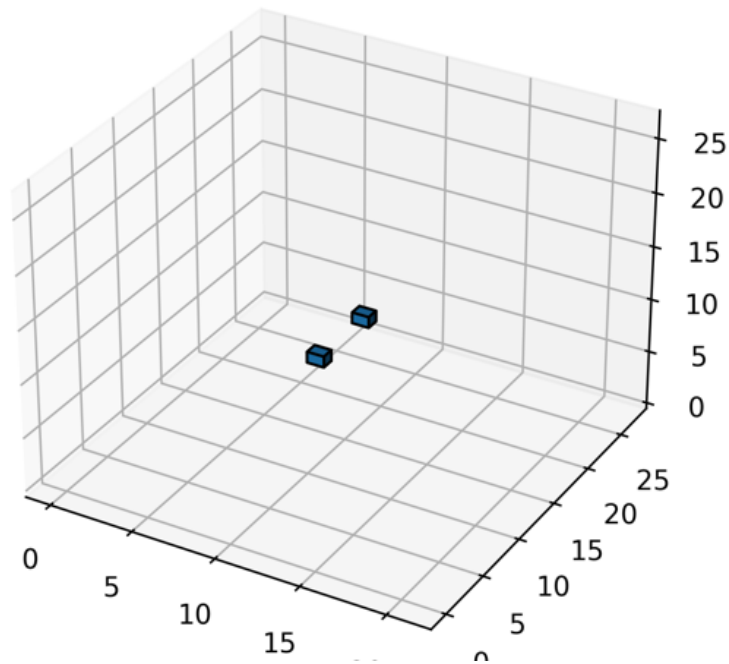
```

plt.rcParams['figure.dpi'] = 300

class Example(Scene):
    def construct(self):
        self.camera.background_color= WHITE
        fig = plt.figure()
        ax = fig.add_subplot(projection='3d')
        x=np.full((21,27,27),0)
        x[10,10,10]=1
        x[10,16,10]=1
        ax.voxels(x, edgecolor='k')
        fig.canvas.draw()
        buf = fig.canvas.buffer_rgba()
        img = ImageMobject(buf).scale(1)
        plt.close(fig)
        self.add(img)

```





```
[4]: %%manim $paramp

plt.rcParams['figure.dpi'] = 300

def my_function(amplitude, x):
    return amplitude * np.sin(x)

def mpl_image3d_plt(amp1,x):
    fig = plt.figure()
    ax = fig.add_subplot(projection='3d')
    ax.view_init(elev=40+3*np.sin(amp1), azim=20+10*np.cos(amp1))
    ax.voxels(x, edgecolor='k')
    ax.axes.xaxis.set_ticklabels([])
    ax.axes.yaxis.set_ticklabels([])
    ax.axes.zaxis.set_ticklabels([])
    fig.canvas.draw()
    buf = fig.canvas.buffer_rgba()
    img = ImageMobject(buf).scale(1)
    plt.close(fig)
    return img

class Example(Scene):
    def construct(self):
        self.camera.background_color= WHITE
        x=np.full((21,27,27),0)
        x[10,10,10]=1
        x[10,16,10]=1
        amp1=0
```

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```

amp2=TAU
tr_amplitude = ValueTracker(amp1)
image = mpl_image3d_plt(amp1, x)
self.add(image)

def update_image(mob):
    new_mob = mpl_image3d_plt(tr_amplitude.get_value(), x)
    mob.become(new_mob)

image.add_updater(update_image)
self.play(tr_amplitude.animate.set_value(amp2), run_time=4)

```

```
<IPython.core.display.Video object>
```

## 1.8.2 Animations with OpenGL

Just add the `--renderer=opengl` flag, and animations will render with the OpenGL backend, which is still under development. Here are two examples: one for rendering a video (needs additional the `--write_to_movie` flag) and one for a static 3D scene (including it)

```

[5]: paramGL = "-v WARNING -s -ql --renderer=opengl --disable_caching --progress_bar None_
↳Example"
paramHGL = "-v WARNING -s -qh --renderer=opengl --disable_caching --progress_bar None_
↳Example"
parampGL = "-v WARNING -ql --renderer=opengl --write_to_movie --disable_caching --
↳progress_bar None Example"
parampHGL = "-v WARNING -qh --renderer=opengl --write_to_movie --disable_caching --
↳progress_bar None Example"

```

```

[6]: %%time
%%manim $parampHGL
class Example(Scene):
    def construct(self):
        dot= Dot(color= YELLOW, radius=0.5)
        self.play(dot.animate.shift(2*RIGHT).scale(2).set_color(BLUE))
        self.wait()

```

```
<IPython.core.display.Video object>
```

```

CPU times: user 1.15 s, sys: 479 ms, total: 1.63 s
Wall time: 4.47 s

```

```

[7]: %%time
%%manim $parampGL
class Example(ThreeDScene):
    def construct(self):
        resolution_fa = 42
        self.set_camera_orientation(phi=75 * DEGREES, theta=-30 * DEGREES)

    def param_gauss(u, v):
        x = u

```

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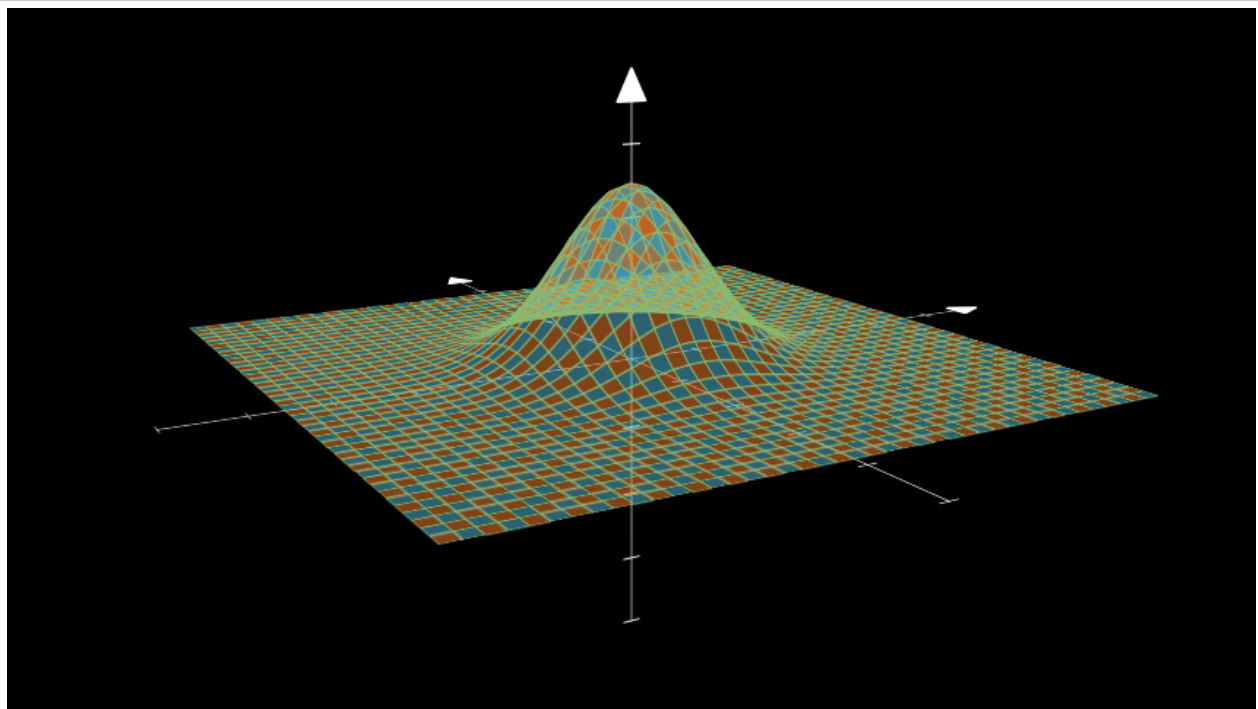
```

y = v
sigma, mu = 0.4, [0.0, 0.0]
d = np.linalg.norm(np.array([x - mu[0], y - mu[1]]))
z = np.exp(-(d ** 2 / (2.0 * sigma ** 2)))
return np.array([x, y, z])

gauss_plane = Surface(
    param_gauss,
    resolution=(resolution_fa, resolution_fa),
    v_range=[-2, +2],
    u_range=[-2, +2]
)

gauss_plane.scale(2, about_point=ORIGIN)
gauss_plane.set_style(fill_opacity=1, stroke_color=GREEN)
gauss_plane.set_fill_by_checkerboard(ORANGE, BLUE, opacity=0.5)
axes = ThreeDAxes()
self.add(axes, gauss_plane)

```



CPU times: user 4.6 s, sys: 93.9 ms, total: 4.69 s  
 Wall time: 4.56 s

```

[8]: %%time
%%manim $param
## comparison of the same example to cairo:
class Example(ThreeDScene):
    def construct(self):
        resolution_fa = 42
        self.set_camera_orientation(phi=75 * DEGREES, theta=-30 * DEGREES)

```

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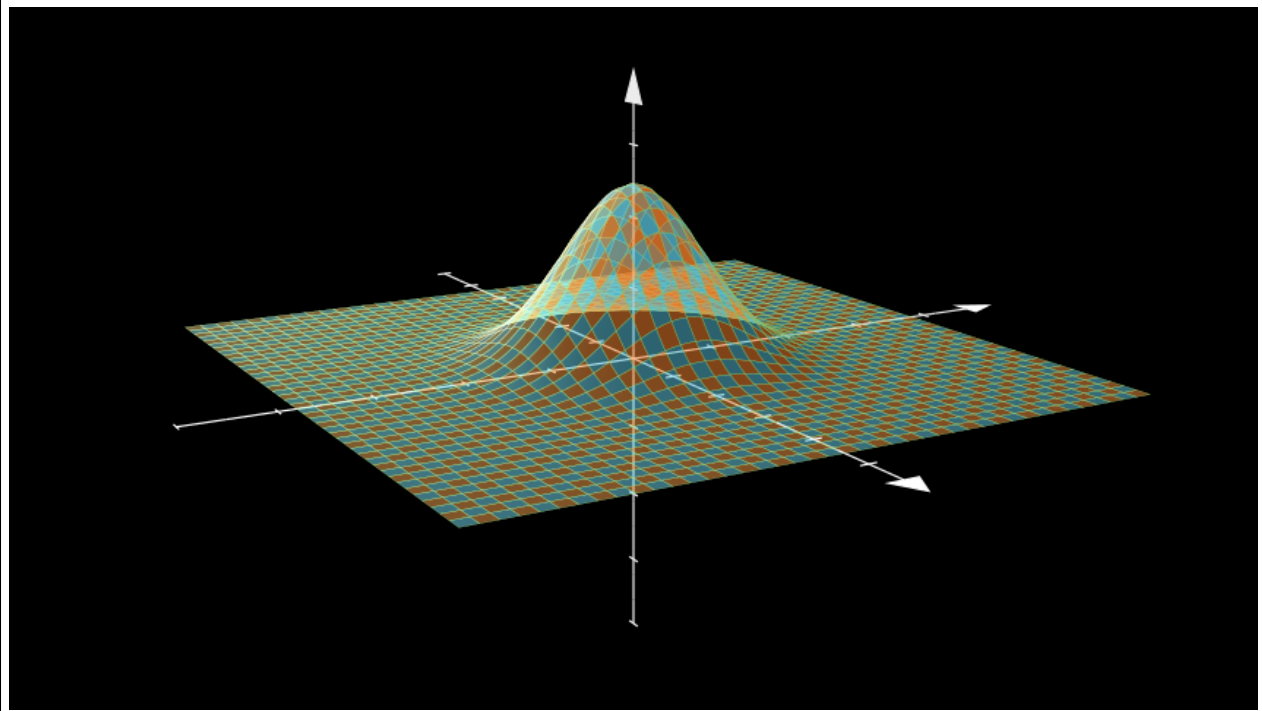
```

def param_gauss(u, v):
    x = u
    y = v
    sigma, mu = 0.4, [0.0, 0.0]
    d = np.linalg.norm(np.array([x - mu[0], y - mu[1]]))
    z = np.exp(-(d ** 2 / (2.0 * sigma ** 2)))
    return np.array([x, y, z])

gauss_plane = Surface(
    param_gauss,
    resolution=(resolution_fa, resolution_fa),
    v_range=[-2, +2],
    u_range=[-2, +2]
)

gauss_plane.scale(2, about_point=ORIGIN)
gauss_plane.set_style(fill_opacity=1, stroke_color=GREEN)
gauss_plane.set_fill_by_checkerboard(ORANGE, BLUE, opacity=0.5)
axes = ThreeDAxes()
self.add(axes, gauss_plane)

```



CPU times: user 1min 26s, sys: 99.7 ms, total: 1min 27s  
 Wall time: 1min 26s

[ ]:

## 1.9 Changelog

### 1.9.1 0.17.1

- Animation example for `low_frame_rate`
- Animation example for different rate functions simultaneously.
- `config.media_embed = True` for videos in FlyingFrames

### 1.9.2 0.15.2

- rerun examples with latest manim version.

### 1.9.3 0.13.0

- Moon Mobject in chapter 3
- added transparent background example ## 0.12.0
- `stretch_in_place` to stretch
- renamed all params to param
- added openGL param in TL;DR
- added chapter with manim+matplotlib
- added Boolean examples to mobject gallery

### 1.9.4 0.11.0

- Removing “Last Edited”
- Update Version
- added new Banner
- Removing numbers in chaptername
- adding chapter “Scene Building with plots”
- removing chapter “additional tools”
- Reordering chapters

### 1.9.5 0.10.0

- changed plugin to `manim_physics`
- Added copy-paste gallery in chapter 2 as a link to <https://kolibril13.github.io/mobject-gallery/>

### 1.9.6 0.9.0

- added copybutton
- updated manim version
- Shortened headings

Repository on GitHub: <https://github.com/kolibril13/flyingframes>