

quiz1

November 13, 2024

1 Quiz 1

LIS MASc

Engaging Complexity

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```
[316]: import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

plt.style.use("default")
# plt.rcParams["figure.dpi"] = 300
```

1.1 1

1.1.1 (a)

```
[317]: def laminar_flow(radius):
        return 18500 * (0.25 - radius**2)

a1 = 0.1
a2 = 0.4

print(f"v({a1}) =", laminar_flow(a1))
print(f"v({a2}) =", laminar_flow(a2))
```

$v(0.1) = 4440.0$

$v(0.4) = 1664.9999999999993$

1.1.2 (b)

The blood flows faster near the center of the artery and decreases with distance in a nonlinear way.

1.1.3 (c)

```
[318]: values = np.linspace(0, 0.5, 6)
data = {'r': values, 'v(r)': laminar_flow(values)}
pd.DataFrame(data)
```

```
[318]:      r    v(r)
0  0.0  4625.0
1  0.1  4440.0
2  0.2  3885.0
3  0.3  2960.0
4  0.4  1665.0
5  0.5    0.0
```

1.1.4 (d)

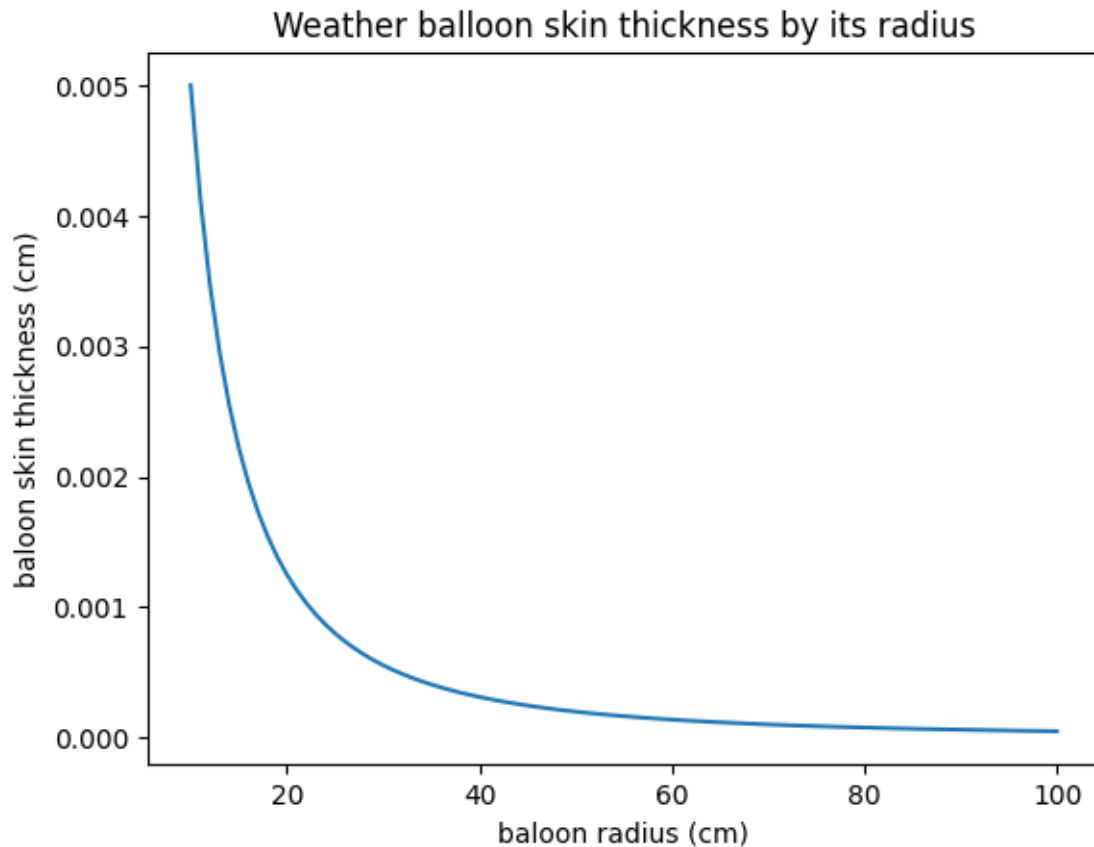
1.2 2

1.2.1 (a)

```
[319]: def baloon_thickness_cm(radius_cm):
        return 0.5 / (radius_cm * radius_cm)
```

```
[320]: values = np.arange(10, 101)

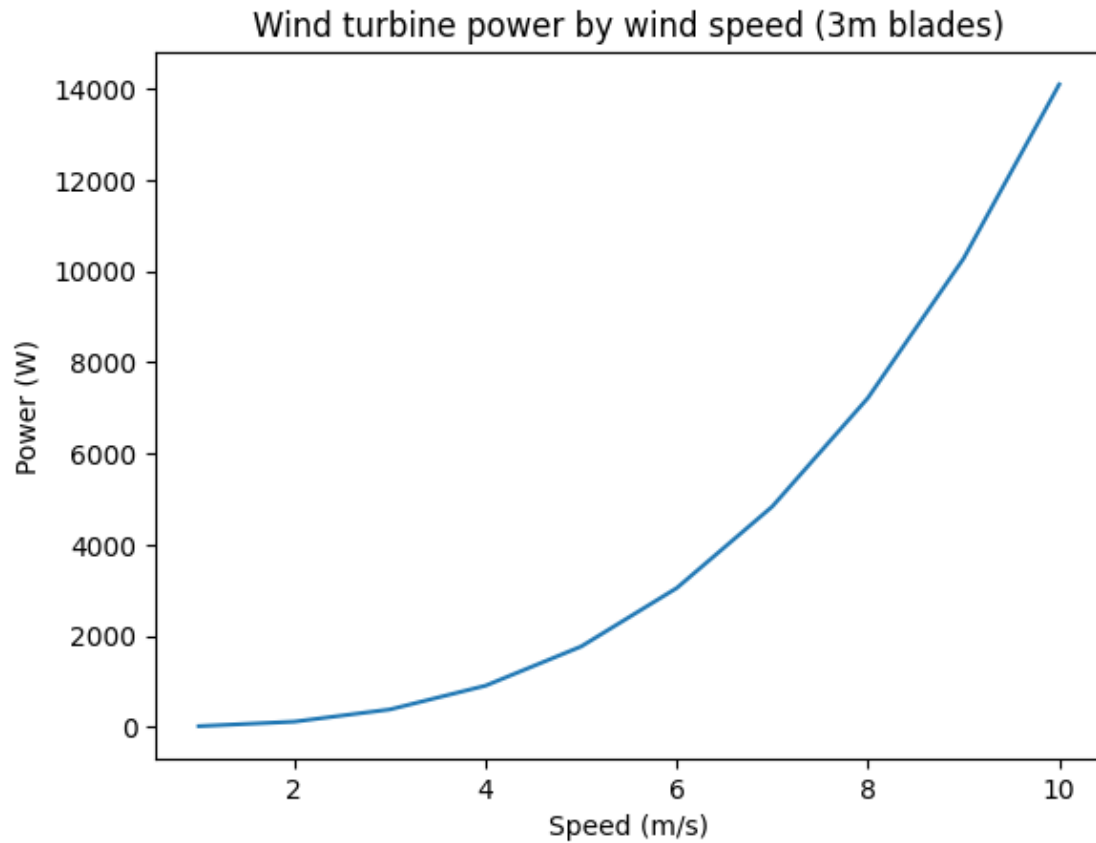
plt.plot(values, baloon_thickness_cm(values))
plt.xlabel("baloon radius (cm)")
plt.ylabel("baloon skin thickness (cm)")
plt.title("Weather balloon skin thickness by its radius");
```



1.2.2 (b)

```
[321]: def wind_power_w(speed_mps):  
        return 14.1 * speed_mps * speed_mps * speed_mps
```

```
[322]: values = np.arange(1, 11)  
  
plt.plot(values, wind_power_w(values))  
plt.xlabel("Speed (m/s)")  
plt.ylabel("Power (W)")  
plt.title("Wind turbine power by wind speed (3m blades)");
```



1.3 3

1.3.1 (a)

```
[323]: def a(prev):  
        return 2 * (prev + 3)  
  
print(a(4))  
print(a(a(4)))  
print(a(a(a(4))))  
print(a(a(a(a(4)))))  
print(a(a(a(a(a(4))))))
```

14
34
74
154
314

1.3.2 (b)

```
[324]: def b(prev):  
        return 1 / ( 1 + prev)  
  
        print(b(1))  
        print(b(b(1)))  
        print(b(b(b(1))))  
        print(b(b(b(b(1)))))  
        print(b(b(b(b(b(1))))))
```

```
0.5  
0.6666666666666666  
0.6000000000000001  
0.625  
0.6153846153846154
```

1.3.3 (c)

```
[325]: def c(prev: int, pprev: int, iteration=0, max=5) -> int:  
        if iteration > max:  
            return prev  
  
        value = prev - pprev  
        iteration += 1  
        print(value)  
        return c(value, prev, iteration, max=max)  
  
        c(3, 1, max=5)
```

```
2  
-1  
-3  
-2  
1  
3
```

[325]: 3

1.4 4

1.4.1 (a)

```
[326]: def a4(n_minus_one, n_minus_two, n_minus_three, iteration=0, max=100,  
        ↪result=[]):  
        if iteration > max:  
            return result
```

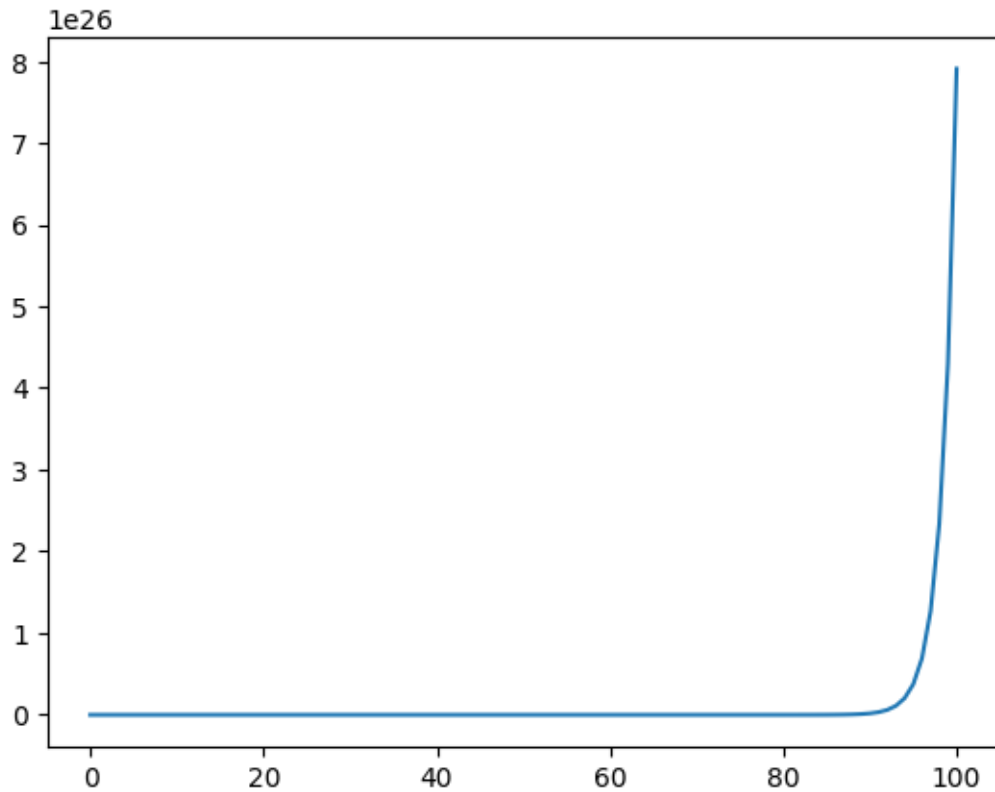
```

n = n_minus_one + n_minus_two + n_minus_three
result.append(n)
iteration += 1

return a4(n, n_minus_one, n_minus_two, iteration, max=max, result=result)

result = a4(1, 1, 1, max=100)
plt.plot(range(len(result)), result);

```



1.4.2 (b)

```

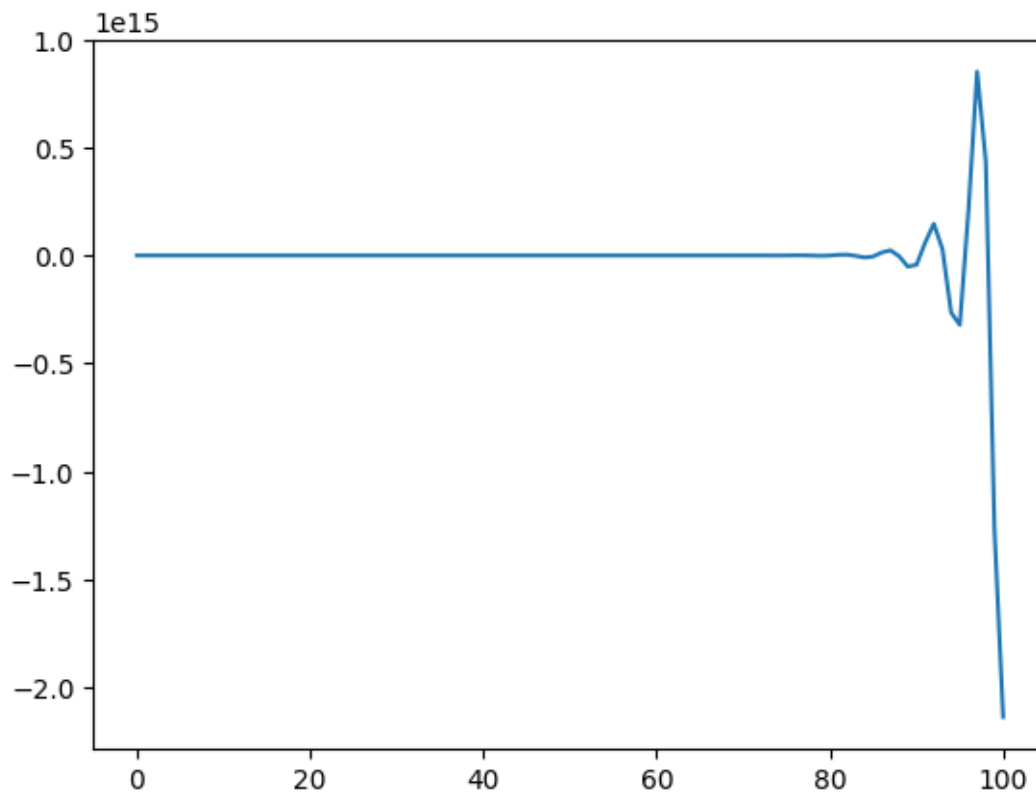
[327]: def b4(n_minus_one, n_minus_two, iteration=0, max=100, result=[]):
        if iteration > max:
            return result

        n = n_minus_one - (2 * n_minus_two)
        result.append(n)
        iteration += 1

        return b4(n, n_minus_one, iteration, max=max, result=result)

```

```
result = b4(1, 1)
plt.plot(range(len(result)), result);
```



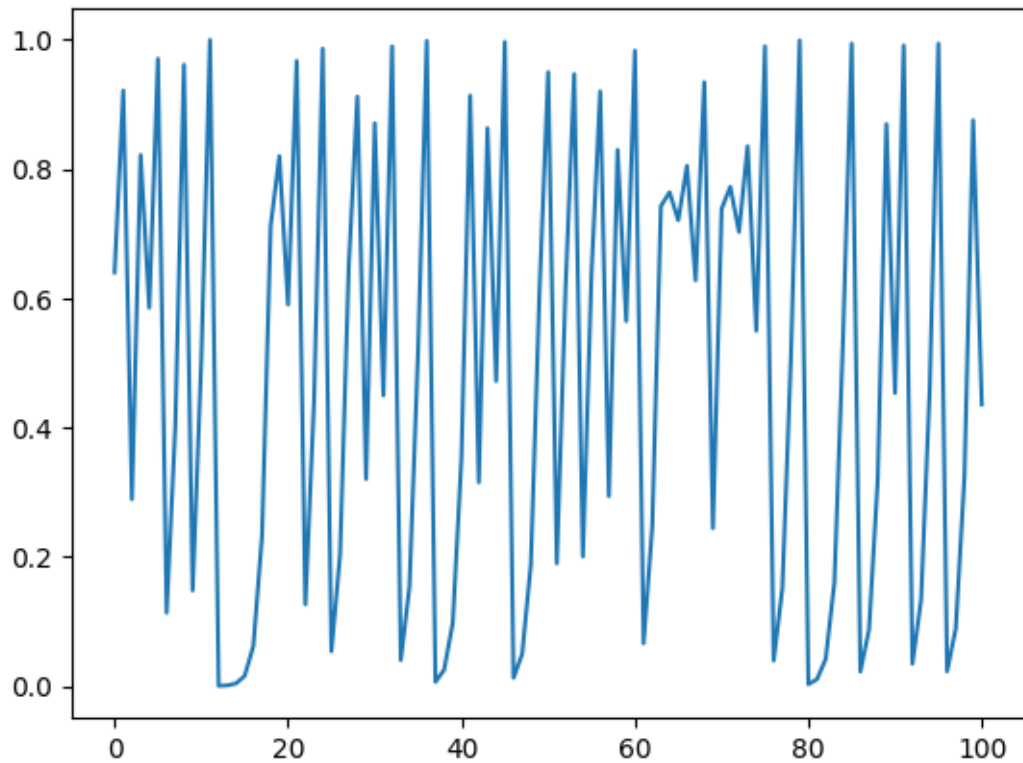
1.4.3 (c)

```
[328]: def c4(n_minus_one, iteration=0, max=100, result=[]):
    if iteration > max:
        return result

    n = (4 * n_minus_one) * (1 - n_minus_one)
    result.append(n)
    iteration += 1

    return c4(n, iteration, max=max, result=result)

result = c4(0.2)
plt.plot(range(len(result)), result); # no way!!!!
```



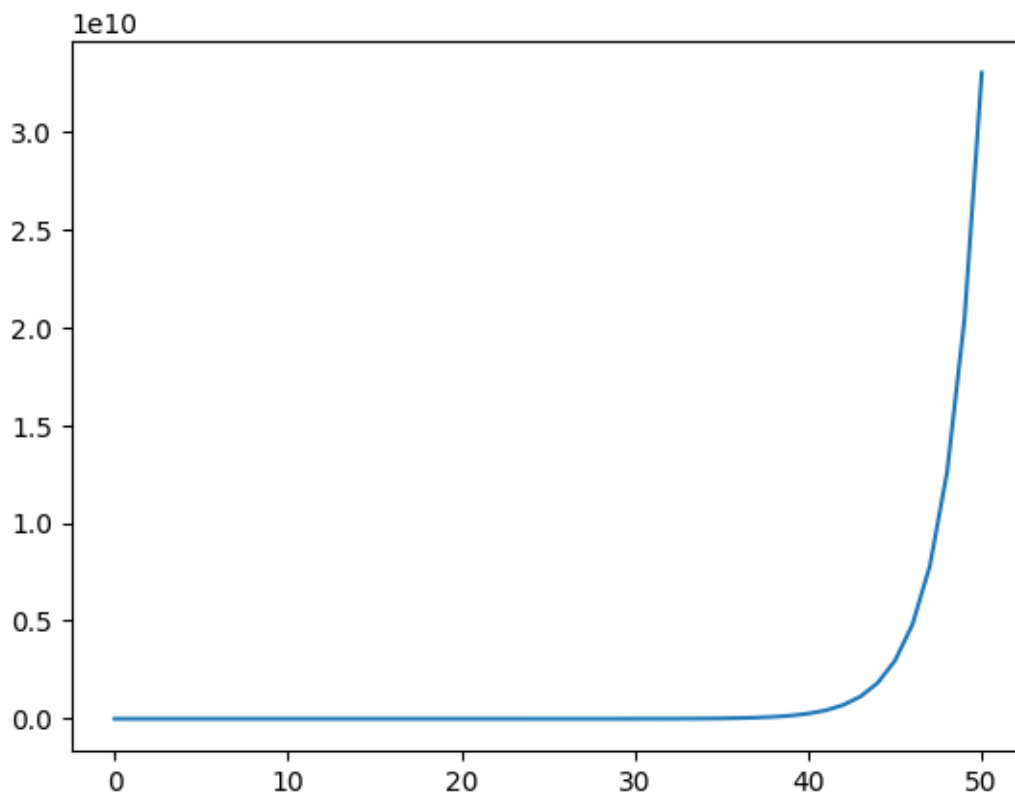
1.5 5

```
[329]: def five(n_minus_one, n_minus_two, iteration=0, max=50, result=[]):
        if iteration > max:
            return result

        n = n_minus_one + n_minus_two
        result.append(n)
        iteration += 1

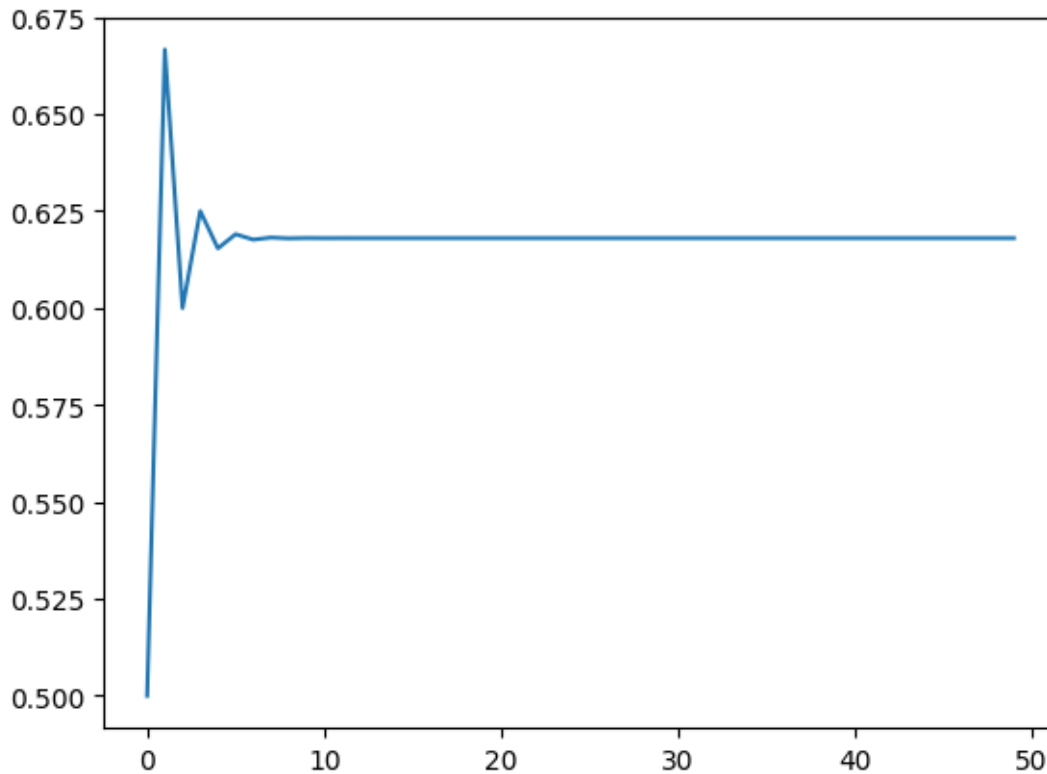
        return five(n, n_minus_one, iteration, max=max, result=result)

result = five(1, 0, max=50)
plt.plot(range(len(result)), result);
```

```
[330]: result_copy = result.copy() # duplicate array
result.pop(0) # shift items back one index
result_copy.pop() # remove last item so arrays have same length
ratios = np.array(result_copy) / np.array(result) # calculate ratios

plt.plot(range(len(ratios)), ratios);
```



```
[331]: ratios[25]
```

```
[331]: np.float64(0.6180339887543226)
```

The first plot shows a simple increasing function; the plot looks exponential even though the function itself is just a sum.

The second plot is very different. It oscillates in the beginning but converges around 0.618 - also known as the golden ratio.

While the long-time behaviour of the first function is to increase, the long-time behaviour of the second one is to stabilize.