Quiz_1

November 13, 2024

1 LIS MASc - Engaging Complexity

Access this notebook on GitHub
PDF generated using nbconvert

[1]:
```
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)

[2]:
```
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)

[3]:
```
values = np.linspace(0, 0.5, 6)
data = {'r': values, 'v(r)': laminar_flow(values)}
pd.DataFrame(data)
```

[3]:

	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)

(if the image does not show on the pdf, you can find it on the notebook linked at the top of the page)

1.2 2

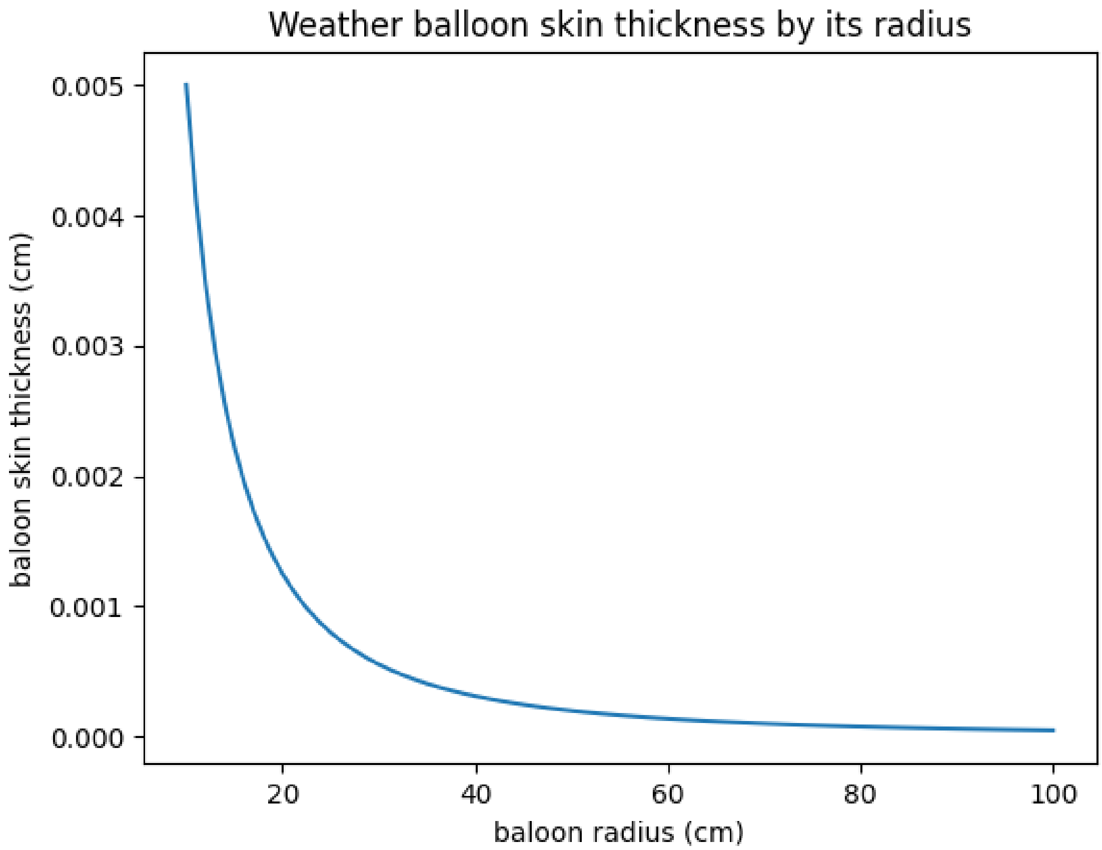
1.2.1 (a)

[4]:

```python
def baloon_thickness_cm(radius_cm):
    return 0.5 / (radius_cm * radius_cm)
```

[5]:

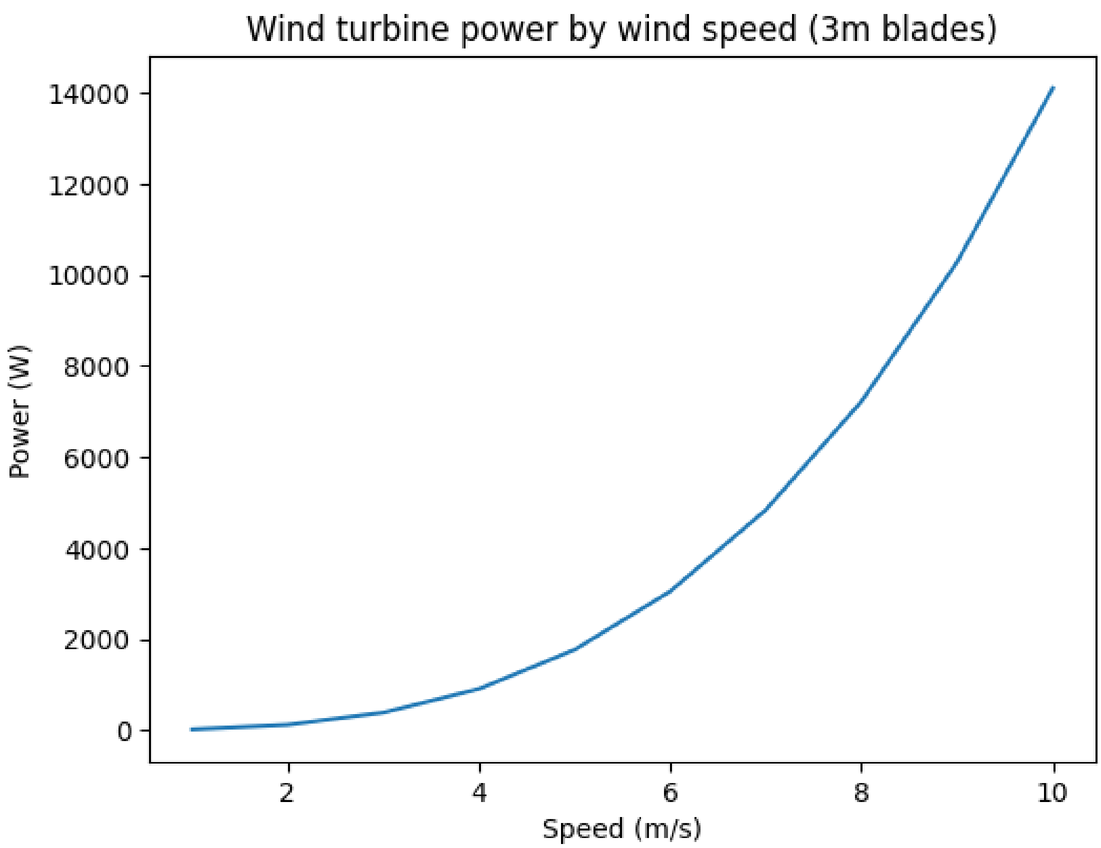
```python
values = np.arange(10, 101)

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)

[6]:
```
def wind_power_w(speed_mps):
    return 14.1 * speed_mps * speed_mps * speed_mps
```

[7]:
```
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)

[8]:
```
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)

[9]:
```
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)

[10]:
```
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
```

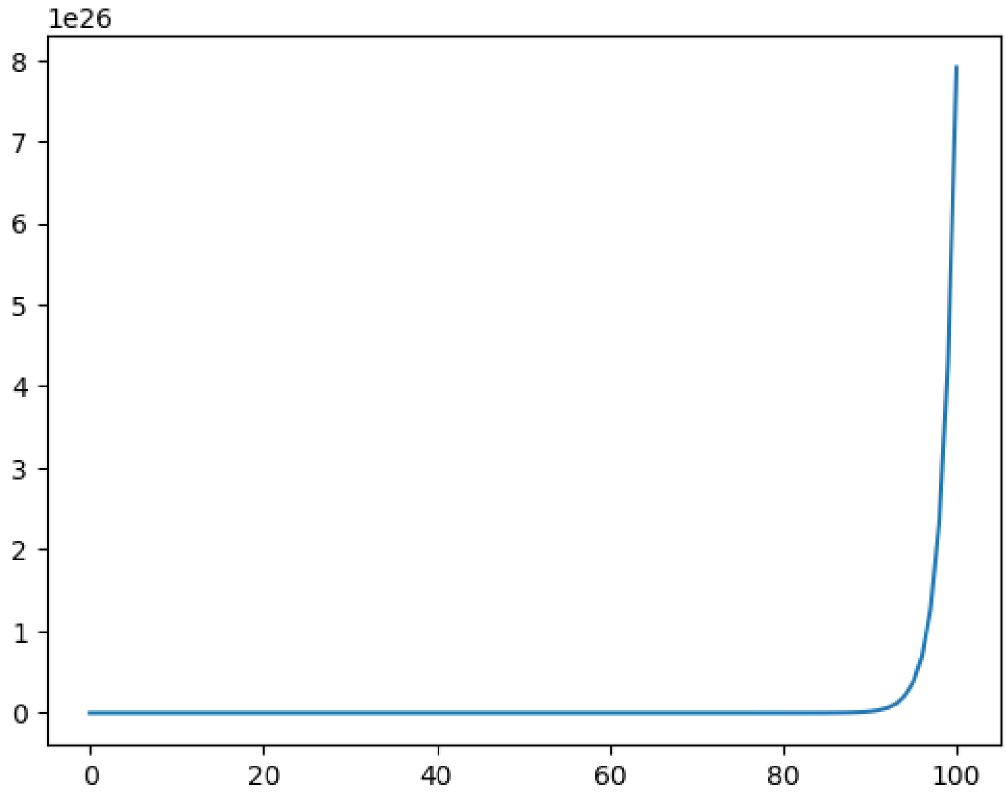
[10]: 3

1.4 4

1.4.1 (a)

[11]:
```
def a4(n_minus_one, n_minus_two, n_minus_three, iteration=0, max=100,␣
 ↪result=[]):
    if iteration > max:
        return result

```

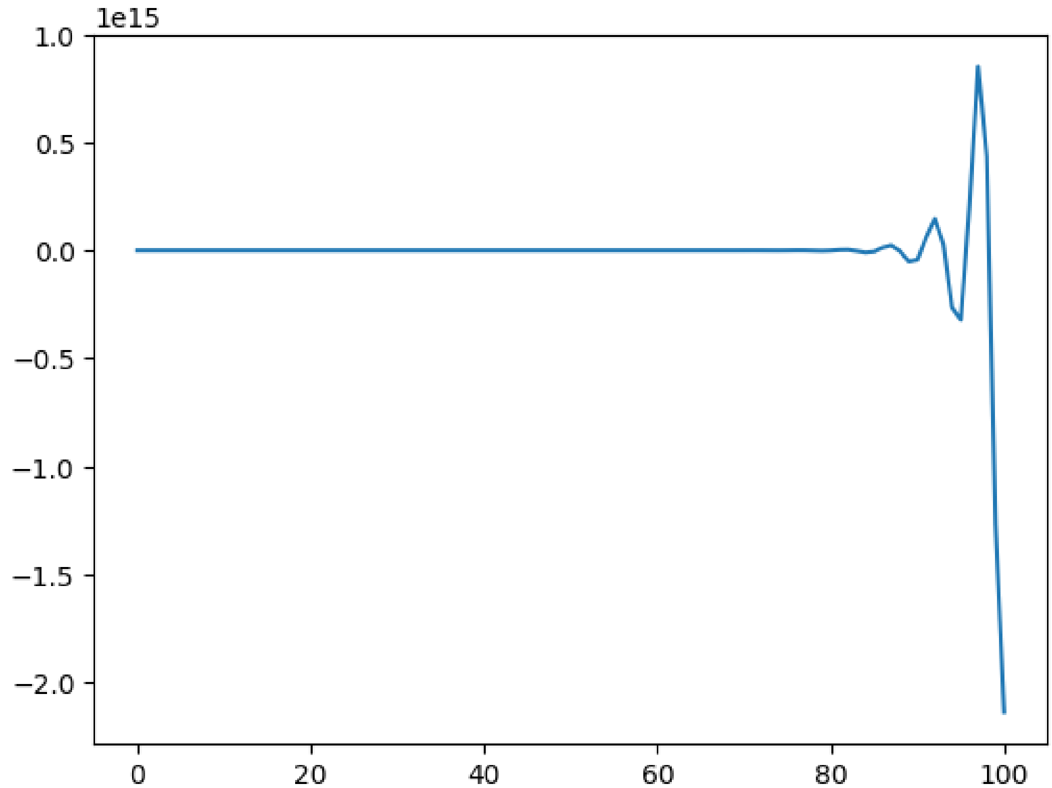
```
    n = n_minus_one + n_minus_two + n_minus_three
    result.append(n)
    iteration += 1

    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)

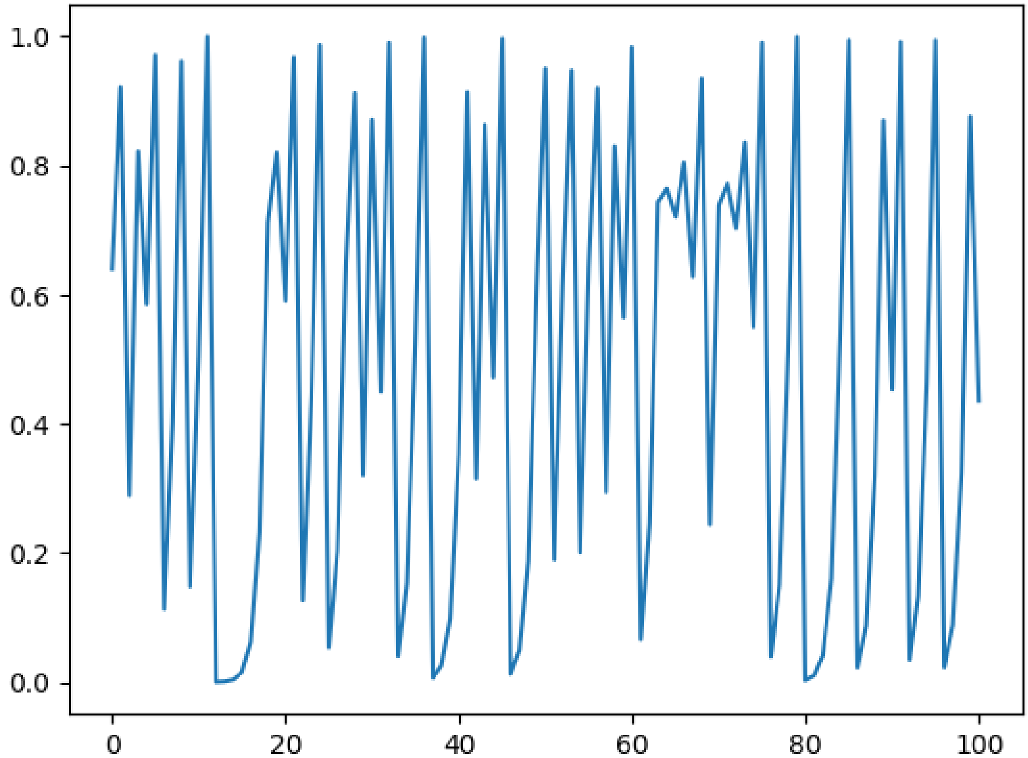
[12]:
```
def b4(n_minus_one, n_minus_two, iteration=0, max=100, result=[]):
    if iteration > max:
        return result

    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);
```



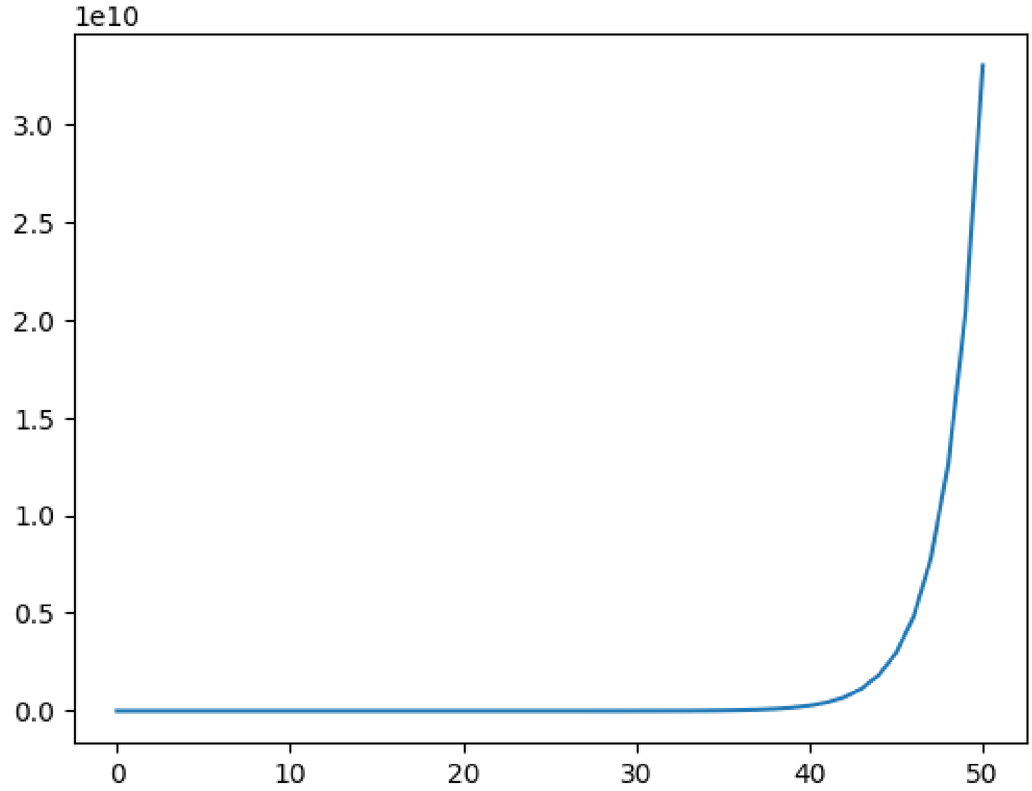
1.4.3 (c)

[13]:
```
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!!!!!
```

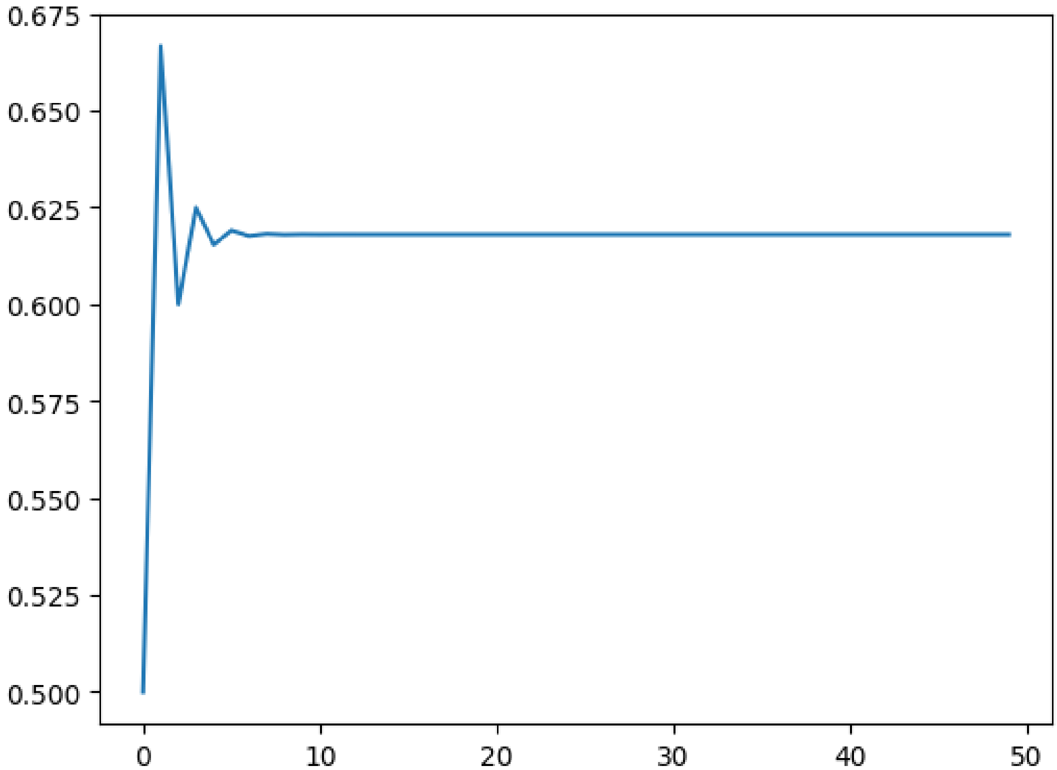


1.5 5

[14]:
```
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);
```



[15]:
```
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);
```



[16]:
```
ratios[25]
```

[16]:
```
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.