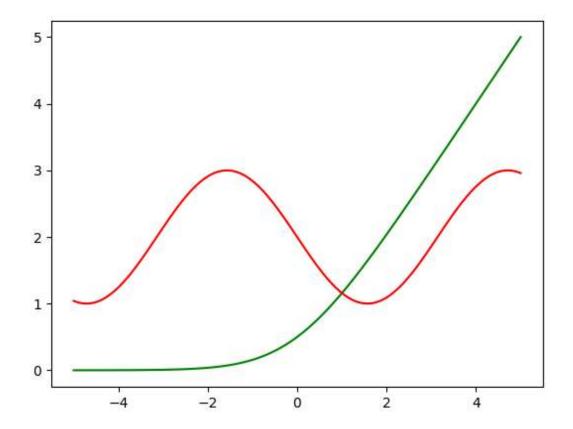
# Лабораторная работа 1

## Задание 1

10) 
$$\begin{cases} e^{-2x} + \frac{x}{y} = 1, \\ \sin x + y = 2; \end{cases}$$







Точка пересечения двух графиков (1.002, 1.158):

X принадлежит (0, 1), Y принадлежит (0, 1.6)

Поэтому я взял начальное значения x0, y0 = 0.5, 0.8.

Значение h = [0.000005, 0.000005] было выбрано экспериментальным путем, были выбраны различные h и чем меньше оно становилось, тем точнее становился ответ. Остановился на данном h так как дальнейшее его уменьшение приводит к ухудшению алгоритма.

### Дискретный метода Ньютона

```
import matplotlib.pyplot as plt
import numpy as np
def secondFun(x, y):
def graph():
```

### Результат:

```
Итерации:
1
2
3
4
5
х, у:
1.0015074076751147 1.1577155156855803
f1:
0.0
f2
0.0
```

#### Метода Ньютона

```
import matplotlib.pyplot as plt
import numpy as np
def graph():
```

```
i += 1
    print(i)
    v = np.array([-firstFun(x, y), -secondFun(x, y)])
    A = np.array(jacobi(x, y))
    xt = np.linalg.solve(A, v)
    x += xt[0]
    y += xt[1]
    print("x, y:")
    print(x, y)
    print("f1:")
    print(firstFun(x, y))
    print("f2")
    print(secondFun(x, y))
```

## Результат:

```
Итерации:
1
2
3
4
5
x, y:
1.0015074076751147 1.1577155156855803
f1:
0.0
f2
0.0
```

### Вывод:

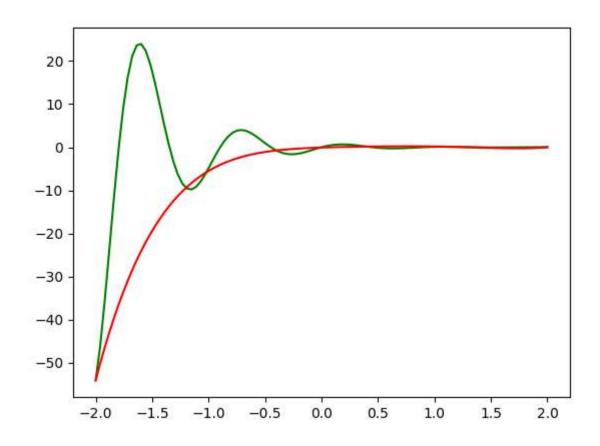
Два этих метода сошлись с ответом за равное количество итераций, но дискретный метод Ньютона без правильно подобранного h работал медленнее и менее точно.

## Задание 2

1)

Результат:

Ha 6:



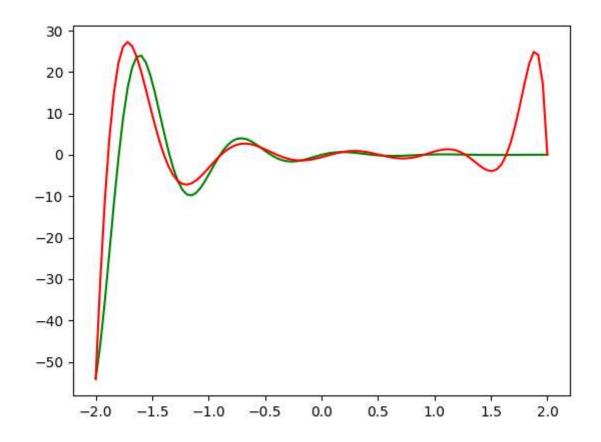
## Время

0.0

## Многочлен

 $0.39607645663383 *x^5 + -1.3849184285386138 *x^4 + 1.5830005895313266 *x^3 + -1.2012621840666753 *x^2 + 0.8566424949264662 *x^1 + -0.06984911889416975 *x^0$ 

Ha 12:

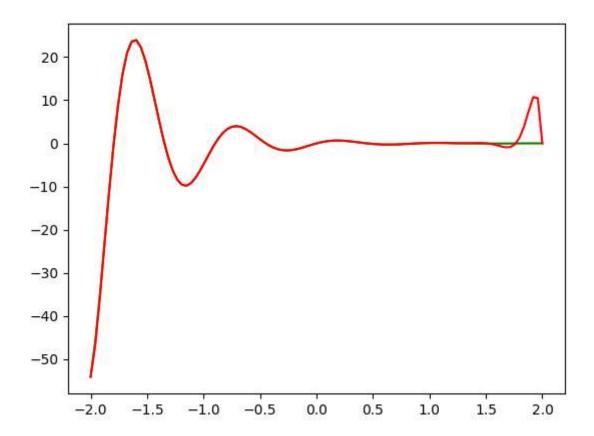


### 0.0009965

#### Многочлен

 $-1.7861073881485101 *x^ 11 + -0.921921382766293 *x^ 10 + \\ 18.88672066472061 *x^ 9 + 5.088049754662393 *x^ 8 + -68.99952544892885 *x^ 7 + -4.624091471178751 *x^ 6 + 102.49858743239899 *x^ 5 + -\\ 7.368198881421811 *x^ 4 + -55.96446948940821 *x^ 3 + 7.223020022245112 *x^ 2 + 7.3494512254840565 *x^ 1 + -0.5858777834522018 *x^ 0$ 

Ha 18:



#### 0.0009965

#### Многочлен

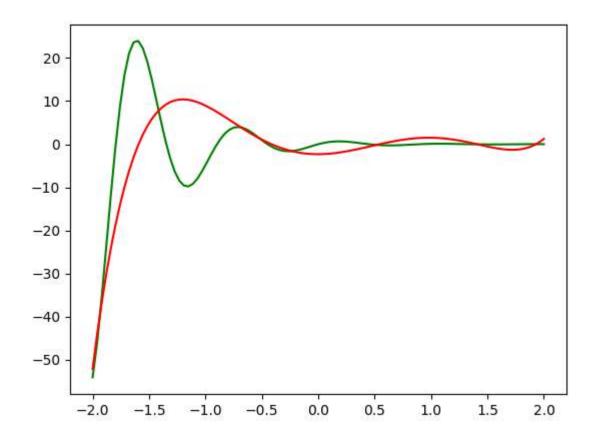
```
-0.19279341312590004 *x^ 17 + 0.00472856059873606 *x^ 16 + \\ 3.1658196707041055 *x^ 15 + -0.9802625686210928 *x^ 14 + - \\ 21.223950462712445 *x^ 13 + 13.178884960627622 *x^ 12 + \\ 72.36585058181198 *x^ 11 + -70.06888769222283 *x^ 10 + - \\ 123.74364353023665 *x^ 9 + 178.2869489653965 *x^ 8 + 77.53563372468165 *x^ 7 + -215.68739386015463 *x^ 6 + 30.76175076860064 *x^ 5 + \\ 107.04178234277438 *x^ 4 + -43.195137249558876 *x^ 3 + - \\ 14.15260244348828 *x^ 2 + 7.000327515664893 *x^ 1 + \\ 0.0017464872932050567 *x^ 0
```

### Вывод:

Для решения данной задачи строились интерполяционные многочлены Лагранжа, исходя из результатов видно, что чем больше x-ов мы берем, тем более точное приближение в итоге выходит. 2)

Результат:

Ha 6:



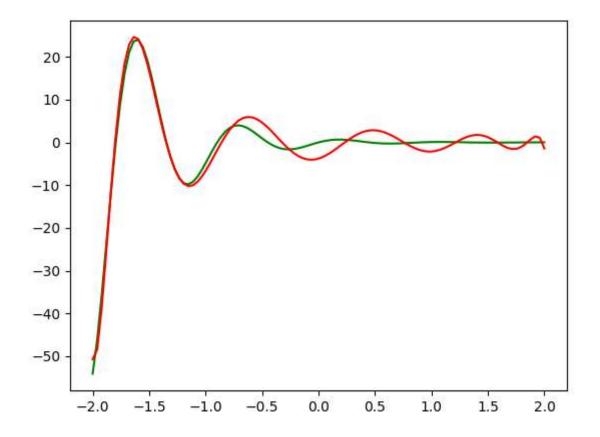
## Время

0.0

## Многочлен

 $2.3708500036291853 *x^5 + -4.442546531033052 *x^4 + -6.163843393501975 *x^3 + 11.985904315319333 *x^2 + 0.06785858051448454 *x^1 + -2.311543444285031 *x^0$ 

Ha 12:

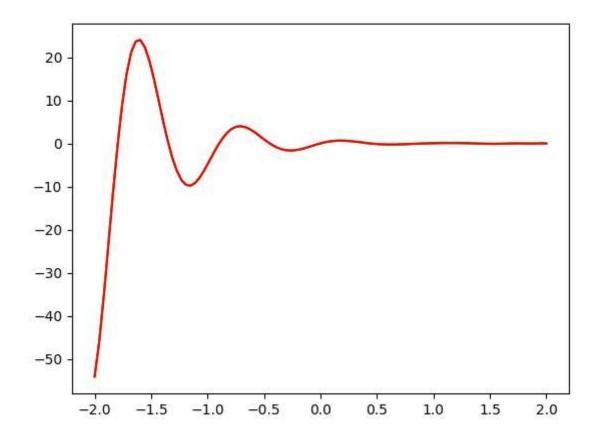


## 0.0009962

### Многочлен

 $-2.1818358019466957 *x^ 11 + 2.6122101840052903 *x^ 10 + \\ 22.672975000990427 *x^ 9 + -26.75159386277393 *x^ 8 + -81.60467927018277 *x^ 7 + 92.66258150315407 *x^ 6 + 119.59928091920848 *x^ 5 + -125.21943556731338 *x^ 4 + -64.1420873285202 *x^ 3 + 56.088446756666464 *x^ 2 + 7.927473853889397 *x^ 1 + -3.7923219020564165 *x^ 0$ 

Ha 18:



0.0029918

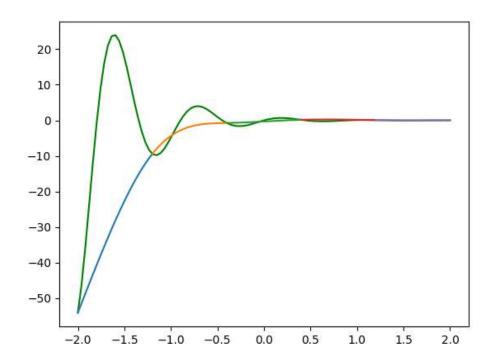
#### Многочлен

```
-0.1101258776649035 *x^ 17 + 0.12308052229236022 *x^ 16 + \\ 2.0311339025469364 *x^ 15 + -2.570478688613111 *x^ 14 + -\\ 14.981558211517957 *x^ 13 + 21.714056435206473 *x^ 12 + \\ 54.69506821689524 *x^ 11 + -93.57433347768182 *x^ 10 + -\\ 96.30587418371387 *x^ 9 + 213.74020568228292 *x^ 8 + 54.57298725586793 *x^ 7 + -244.53114139019038 *x^ 6 + 40.1612667507776 *x^ 5 + \\ 118.55984151983895 *x^ 4 + -44.66760471401568 *x^ 3 + -\\ 15.917422330911355 *x^ 2 + 7.041018646617261 *x^ 1 + 0.04683094941855004 *x^ 0
```

#### Вывод:

Для решения данной задачи строились интерполяционные многочлены Лагранжа на узлах Чебышёва, исходя из результатов видно, что чем больше х-ов мы берем, тем более точное приближение в итоге выходит. 3)

### Ha 6:



### Время

0.0

#### Сплайн

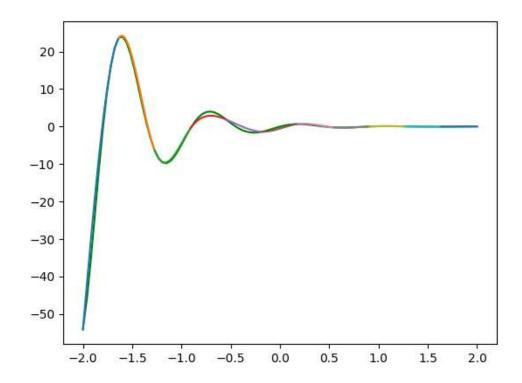
 $-9.420394498560837 + 33.07217933955806 *(x--1.2) + (-85.34620809355087 *(x--1.2)^2)/2 + (-106.68276011693858 *(x--1.2)^3)/6$ 

 $0.15051987850109588 + 0.7192814437739052 *(x-0.40000000000000036) + (-3.491891298533832 *(x-0.4000000000000036)^2)/2 + (-9.337273281057502) *(x-0.400000000000036)^3)/6$ 

 $0.07752746382513545 + -0.31552792316912937 *(x-1.2000000000000000) + (0.9048678811762456 *(x-1.20000000000000) ^2)/2+(5.495948974637597 *(x-1.2000000000000) ^3)/6$ 

 $0.018143606607431098 + 0.04641922930136898 *(x-2.0) + (0*(x-2.0)^2)/2 + (-1.131084851470307 *(x-2.0)^3)/6$ 

Ha 12:



0

#### Сплайн

 $-0.495096088445911 + 36.839207354985035 *(x--0.909090909090909) + (-238.29028300148508 *(x--0.90909090909090)^2)/2 + (-2914.757957749684 *(x--0.909090909090)^3)/6$ 

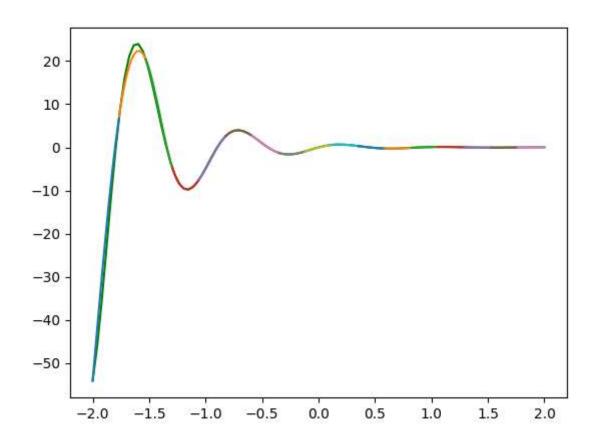
 $-1.3751185937900527 + -0.5378436297810527 *(x -0.18181818181818166) + (81.16147832144304 *(x -0.1818181818181818166)^2)/2 + (289.80590702120406 *(x -0.1818181818181866)^3)/6$ 

 $0.6644917941298372 + 3.1458405378206584 *(x-0.1818181818181818166)+(-60.901215399633585 *(x-0.1818181818181818166)^2)/2+(-390.6724077329608 *(x-0.181818181818166)^3)/6$ 

 $0.013044782239681472 + 1.2236520146832168 *(x-0.909090909090909) + (-10.073197759218663 *(x-0.909090909090909) ^2)/2 + (-110.7545612250462 *(x-0.909090909090) ^3)/6$ 

 $0.018143606607431098 + 0.21217024006270765 *(x-2.0) + (0*(x-2.0)^2)/2 + (-3.1231390163501285 *(x-2.0)^3)/6$ 

#### Ha 18:



0.0010071

#### Сплайн

- $7.223641437857285 + 177.38999040586296 *(x--1.7647058823529411 )+(-1060.4574595611948 *(x--1.7647058823529411 )^2)/2+(-4506.944203135078 *(x--1.7647058823529411 )^3)/6$
- $20.41484724627662 + -61.8324056295328 *(x--1.5294117647058822 )+(-972.9329067396686 *(x--1.5294117647058822 )^2)/2+(371.9793494914863 *(x--1.5294117647058822 )^3)/6$
- -4.761524542783775 + -82.87123414090536 \*(x- -1.2941176470588236 )+( 794.102864393001 \*(x- -1.2941176470588236 )^2)/2+( 7509.902027313846 \*(x-1.2941176470588236 )^3)/6
- $-7.512028906251004 + 37.249671248427155 *(x--1.0588235294117647 )+(226.92483141632627 *(x--1.0588235294117647 )^2)/2+(-2410.506640150868 *(x--1.0588235294117647 )^3)/6$
- $2.572792640958315 + 27.385093239908436 *(x -0.8235294117647058) + (-310.7737444887356 *(x -0.8235294117647058)^2)/2 + (-2285.218947596513 *(x -0.8235294117647058)^3)/6$
- $2.6860787556942634 + -16.764171518258774 *(x -0.5882352941176472 ) + (-64.49500595568576 *(x -0.5882352941176472 )^2)/2 + (1046.6846387654618 *(x -0.5882352941176472 )^3)/6$
- $-1.2594839600377352 + -9.189933829573004 *(x--0.3529411764705883 ) + (128.87602630951474 *(x--0.3529411764705883 )^2)/2 + (128.87602630951474 *(x--0.3529411764705883 )^3)/6$
- $-0.9281456459623966 + 7.442545715428357 *(x -0.11764705882352944 ) + (12.50004982299677 *(x -0.11764705882352944 )^2)/2 + (-494.5979000677014 *(x -0.11764705882352944 )^3)/6$
- $0.5797520031103606 + 2.870009497997787 *(x-0.11764705882352944)+(-51.36660767115663 *(x-0.11764705882352944)^2)/2+(-271.433294350152 *(x-0.11764705882352944)^3)/6$
- $0.3069523901593665 + -3.1750837468670223 *(x-0.3529411764705883 )+(-0.016684910194224606 *(x-0.3529411764705883 )^2)/2+(218.23717173409023 *(x-0.3529411764705883 )^3)/6$

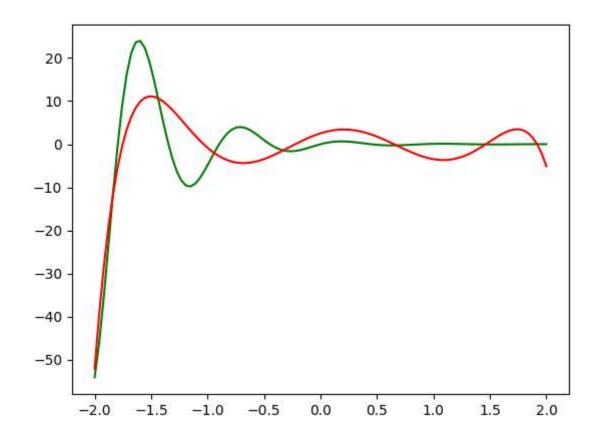
- $-0.255416749015546 + -0.8180761001350034 *(x-0.5882352941176472 ) + (20.051249907416388 *(x-0.5882352941176472 )^2)/2 + (85.2887229748451 *(x-0.5882352941176472 )^3)/6$
- $-0.09545257922995323 + 1.3167247876932162 *(x-0.8235294117647056) + (-1.9054423608764937 *(x-0.8235294117647056)^2)/2 + (-93.31594214024474) *(x-0.8235294117647056)^3)/6$
- $0.10874076548073479 + 0.19418525918971885 *(x-1.0588235294117645)+(-7.636143631403245 *(x-1.0588235294117645)^2)/2+(-24.355480399738692) *(x-1.0588235294117645)^3)/6$
- $0.026892638563538802 + -0.5335642975850678 *(x-1.2941176470588234 ) + (x-1.450272398817564 *(x-1.2941176470588234 )^2)/2 + (38.61726812843844 *(x-1.2941176470588234 )^3)/6$
- $-0.04498686968775497 + -0.019955417247691065 *(x-1.5294117647058822 ) + (2.9154030840501384 *(x-1.5294117647058822 )^2)/2 + (6.22680541223844 *(x-1.5294117647058822 )^3)/6$
- $-0.006210807561530777 + 0.19131702848119467 *(x-1.7647058823529411 ) + (-1.1195872953546104 *(x-1.7647058823529411 )^2)/2 + (-17.148709112470183 *(x-1.7647058823529411 )^3)/6$
- $0.018143606607431098 + 0.05960087608653463 *(x-2.0)+(0*(x-2.0)^2)/2+(4.758246005257094 *(x-2.0)^3)/6$

#### Вывод:

Для решения данной задачи строится трёхмерный сплайн на n узлах, исходя из результатов видно, что чем больше узлов мы берем, тем более точное приближение в итоге выходит.

**4**)

## Для 6:



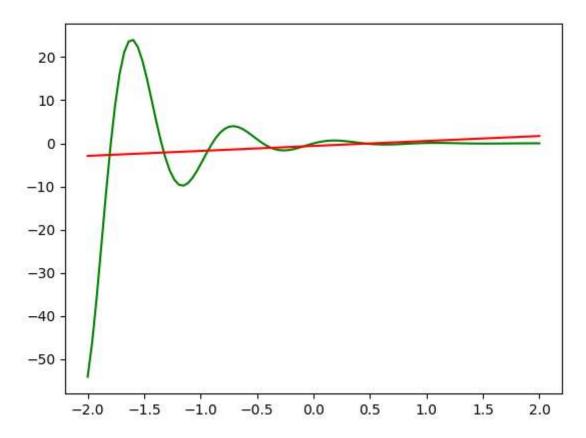
## Время

0.0029916

## Многочлен

 $2.435008147873164 *x^0 + 7.637854804972815 *x^1 + -19.43992803336418 *x^2 + -9.245468165153664 *x^3 + 18.199669772164206 *x^4 + 2.2494555717574496 *x^5 + -3.966754270382547 *x^6$ 

Для 1:

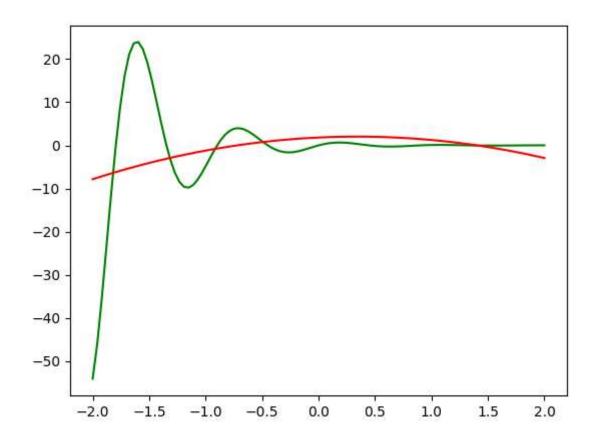


0.0009976

Многочлен

 $-0.9057448746736785 *x^0 + 1.2544854561568086 *x^1$ 

Для 2:

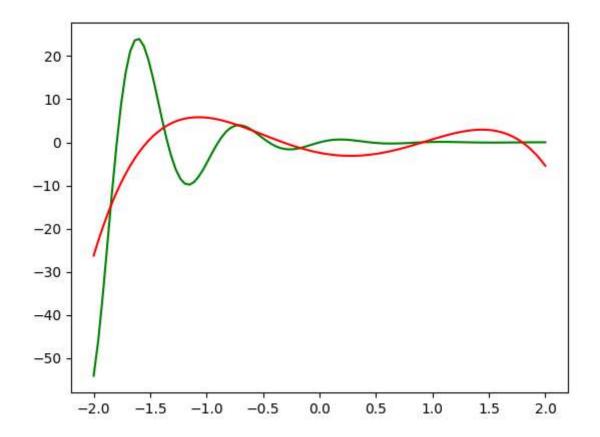


0.0009963

## Многочлен

-0.08502771118287912 \*x^ 0 + -1.8462858180968236 \*x^ 1 + 1.1834365285943915 \*x^ 2

Для 4:



0.0019952

#### Многочлен

-1.5058768708300747 \*x^ 0 + -1.9382220672234898 \*x^ 1 + 5.573343746627696 \*x^ 2 + 0.1514189435735661 \*x^ 3 + -1.3385105473026617 \*x^ 4

#### Вывод:

Для решения данной задачи было построено среднеквадратичное приближение, исходя из результатов видно, что чем больше узлов мы берем, тем более точное приближение в итоге выходит.

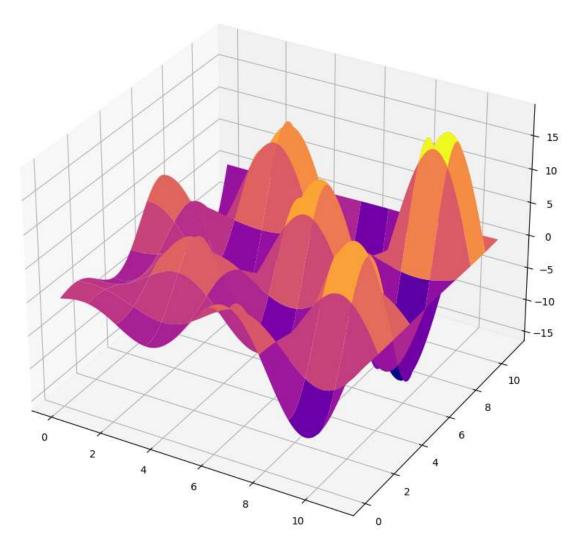
### Итоговый вывод:

Так как при замере времени очень сильно влияло на сколько загружен компьютер, то выбрать лучший алгоритм исходя от времени выполнения не удастся. Однако исходя из графиков можно сказать, что на 18 узлах лучше всего приближает интерполяционный многочлен Лагранжа на узлах Чебышёва.

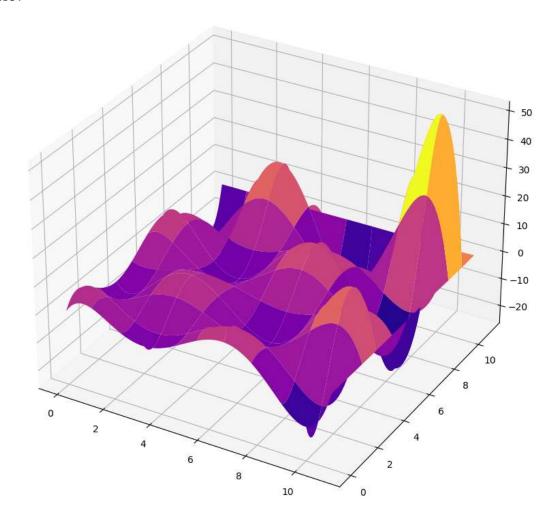
Задание 3

1)

# Исходный график:



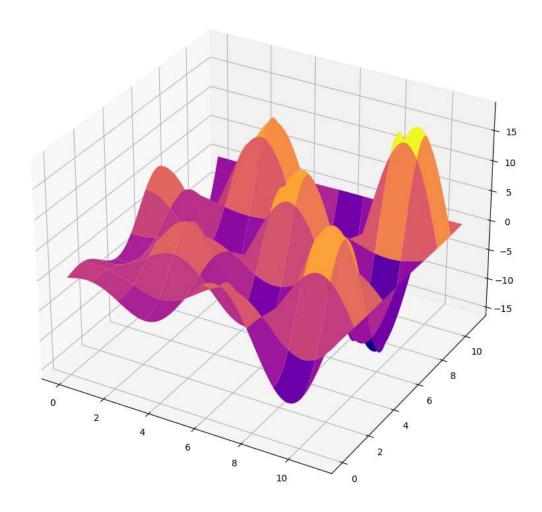
# Ha 6x6:



Время

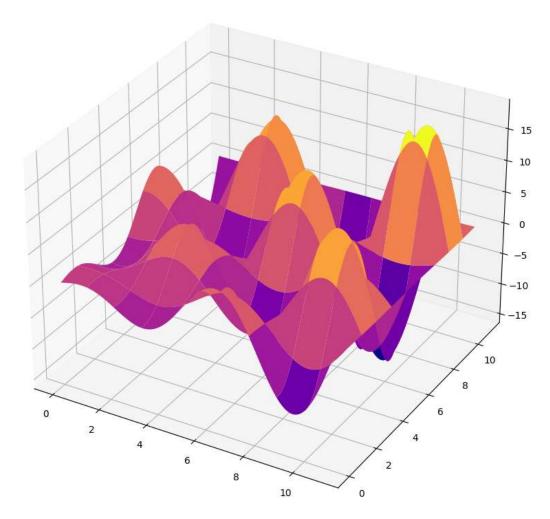
9.8434414 сек

Ha 12x12:



Время 8.9019612 сек

Ha 18x18:



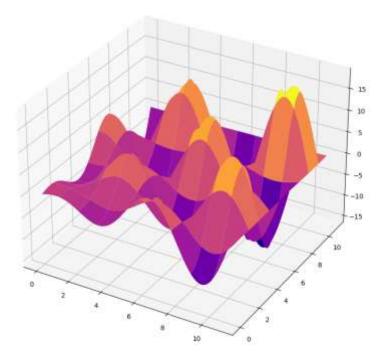
Время

32.3617809 сек

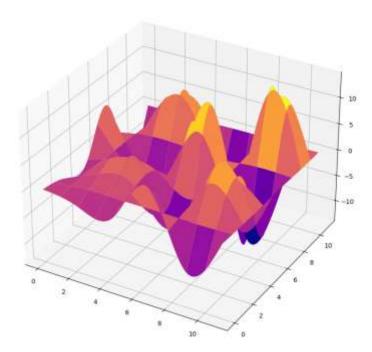
Для решения данной задачи были построены интерполяционные многочлены двух переменных, исходя из результатов видно, что чем больше узлов мы берем, тем более точное приближение в итоге выходит.

2)

# Исходный график



Ha 6x6:



Время

0.0009972 сек

Альфа

```
[[[1.5238676860474776, 1.1937138665205056, -4.9210738897763315,
5.250620594706195, -0.034379772379954626], [1.2422103999876979, -
2.876193782941969, 1.474008037474983, 2.5123071714770613, -
4.859562926933634], [-0.05312433721258447, -3.690879465450749,
7.645608393102523, -6.701700089464271, 0], [-0.024147426005720212, -
1.6535250582900747, 5.152949026615124, -6.521503855712179,
3.0462273133928504]], [[1.1937138665205054, 0.8311907381287138, -
3.212414805970118, 3.2904371785694004, -0.02094650195061061],
[0.9151586072419198, -1.9615104178635596, 0.9225257835432892,
1.6249251570186096, -3.0702241788638585], [-0.33014228832230996, -
2.2850113708644897, 4.906862463052534, -4.268317578074972, 0], [-
0.15006467651014088, -0.8885768557009908, 3.269033560871374, -
4.170536382330684, 1.9401443536704415]], [[-4.9210738897763315, -
3.212414805970118, 11.918834120426968, -11.869196062897455,
0.07401578747923618], [-3.6533442094753346, 7.48537007696581, -
3.3246251753834093, -5.991571089423986, 11.138884533605195],
[1.9557345470187317, 8.170369349745945, -17.99763776097251,
15.57314147548108, 0], [0.888970248644878, 2.824834001239642, -
11.894548686690205, 15.259445107478903, -7.078700670673218]],
[[5.250620594706195, 3.2904371785694004, -11.869196062897455,
11.578545043289344, -0.07107512386500342], [3.8215656023706455, -
7.601930322268728, 3.240951153608382, 5.940090977907844, -
10.912968330195525], [-2.4674347891942237, -7.917561505932479,
17.774726484002578, -15.320963007366704, 0], [-1.1215612678155562, -
2.477330325790116, 11.678312722697752, -15.043495223349673,
6.964074094257592], [[-0.034379772379954626, -0.020946501950610607,
0.07401578747923618, -0.07107512386500342, 0.00043090965899160894], [-
0.024689041870299043, 0.04809625378025672, -0.01988384617001311, -
0.03691808080164899, 0.06721315416718476], [0.01781811454577812,
0.048350336045636204, -0.11015042690951787, 0.09466475906257617, 0
[0.00809914297535369, 0.013878282499935491, -0.07204580134325185,
0.09309781180549728, -0.04302943593753462
```

#### Бэта

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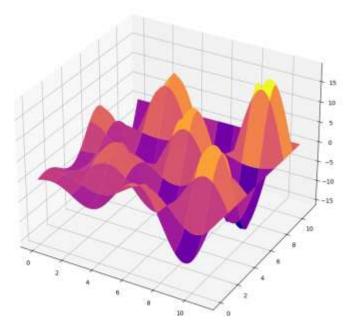
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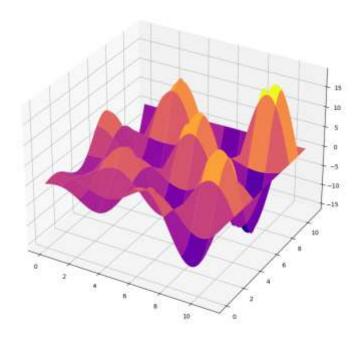
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Для решения данной задачи был построен бикубический сплайн, исходя из результатов видно, что чем больше узлов мы берем, тем более точное приближение в итоге выходит.

## Итоговый вывод:

Исходя из выше приведенных данных видим, что что бикубический сплайн работает лучше.