

# entrega\_01

February 6, 2024

```
[37]: %pip install numpy
      %pip install matplotlib
      %pip install scipy
      %pip install pandas
      %pip install tabulate

      from numpy import random as rd
      import numpy as np
      from typing import List, Callable, Tuple
      import matplotlib.pyplot as plt
      import math
```

Defaulting to user installation because normal site-packages is not writeable  
Requirement already satisfied: numpy in /home/heitor/.local/lib/python3.10/site-packages (1.24.1)

Note: you may need to restart the kernel to use updated packages.

Defaulting to user installation because normal site-packages is not writeable

Requirement already satisfied: matplotlib in

/home/heitor/.local/lib/python3.10/site-packages (3.6.3)

Requirement already satisfied: contourpy>=1.0.1 in

/home/heitor/.local/lib/python3.10/site-packages (from matplotlib) (1.0.7)

Requirement already satisfied: cycler>=0.10 in

/home/heitor/.local/lib/python3.10/site-packages (from matplotlib) (0.11.0)

Requirement already satisfied: fonttools>=4.22.0 in

/home/heitor/.local/lib/python3.10/site-packages (from matplotlib) (4.38.0)

Requirement already satisfied: kiwisolver>=1.0.1 in

/home/heitor/.local/lib/python3.10/site-packages (from matplotlib) (1.4.4)

Requirement already satisfied: numpy>=1.19 in

/home/heitor/.local/lib/python3.10/site-packages (from matplotlib) (1.24.1)

Requirement already satisfied: packaging>=20.0 in

/home/heitor/.local/lib/python3.10/site-packages (from matplotlib) (23.0)

Requirement already satisfied: pillow>=6.2.0 in

/home/heitor/.local/lib/python3.10/site-packages (from matplotlib) (9.4.0)

Requirement already satisfied: pyparsing>=2.2.1 in /usr/lib/python3/dist-packages (from matplotlib) (2.4.7)

Requirement already satisfied: python-dateutil>=2.7 in

/home/heitor/.local/lib/python3.10/site-packages (from matplotlib) (2.8.2)

Requirement already satisfied: six>=1.5 in /usr/lib/python3/dist-packages (from

```
python-dateutil>=2.7->matplotlib) (1.16.0)
Note: you may need to restart the kernel to use updated packages.
Defaulting to user installation because normal site-packages is not writeable
Requirement already satisfied: scipy in /home/heitor/.local/lib/python3.10/site-
packages (1.12.0)
Requirement already satisfied: numpy<1.29.0,>=1.22.4 in
/home/heitor/.local/lib/python3.10/site-packages (from scipy) (1.24.1)
Note: you may need to restart the kernel to use updated packages.
Defaulting to user installation because normal site-packages is not writeable
Requirement already satisfied: pandas in
/home/heitor/.local/lib/python3.10/site-packages (1.5.2)
Requirement already satisfied: python-dateutil>=2.8.1 in
/home/heitor/.local/lib/python3.10/site-packages (from pandas) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in
/home/heitor/.local/lib/python3.10/site-packages (from pandas) (2022.7)
Requirement already satisfied: numpy>=1.21.0 in
/home/heitor/.local/lib/python3.10/site-packages (from pandas) (1.24.1)
Requirement already satisfied: six>=1.5 in /usr/lib/python3/dist-packages (from
python-dateutil>=2.8.1->pandas) (1.16.0)
Note: you may need to restart the kernel to use updated packages.
Defaulting to user installation because normal site-packages is not writeable
Requirement already satisfied: tabulate in
/home/heitor/.local/lib/python3.10/site-packages (0.9.0)
Note: you may need to restart the kernel to use updated packages.
```

# 1 Definindo comportamento

## 1.1 Indivíduo

```
[38]: class Indivíduo():
    def __init__(self,
                genotipo: List[float],
                fn_objetivo: Callable,
                fabric_fn_mutacao: Callable,
                mutation_rate: float = 0.1,
                constrains: List[Callable[[List[float]], bool]] = [],
                is_minimization: bool = True):
        self.genotipo = genotipo
        self.fenotipo = None
        self.fn_objetivo = fn_objetivo
        self.fn_mutacao = fabric_fn_mutacao(mutation_rate)
        self.fabric_fn_mutacao = fabric_fn_mutacao
        self.constrains = constrains
        self.is_minimization = is_minimization

    def get_fenotipo(self) -> float:
        if self.fenotipo == None:
```

```

        for constrain in self.constrains:
            if not constrain(*self.genotipo):
                # Se não estiver de acordo com as restrições, retorna
                ↪ infinito positivo para minimização e infinito negativo para maximização
                self.fenotipo = math.inf if self.is_minimization else -math.
                ↪ inf

                return self.fenotipo
            # Se chego aqui, está de acordo com as restrições
            self.fenotipo = self.fn_objetivo(*self.genotipo)
            return self.fenotipo
        else:
            return self.fenotipo

    def reproduzir_assexuado(self, quant_filhos: int = 1) -> List['Individuo']:
        filhos = []
        for _ in range(quant_filhos):
            genotipo_mutado: List[float] = self.fn_mutacao(self.genotipo)
            filhos.append(Individuo(genotipo_mutado,
                                    self.fn_objetivo, self.fabric_fn_mutacao))

        return filhos

    def reproduzir_sexuado(self, outro: 'Individuo', quant_filhos: int = 1) ->
    ↪ List['Individuo']:
        filhos = []
        for _ in range(quant_filhos):

            genotipo_mutado: List[float] = self.fn_mutacao(
                self.genotipo, outro.genotipo)
            filhos.append(Individuo(genotipo_mutado,
                                    self.fn_objetivo, self.fabric_fn_mutacao))

        return filhos

    def __str__(self) -> str:
        return f"({self.genotipo}, {self.get_fenotipo()})"

    def __lt__(self, obj):
        return ((self.get_fenotipo()) < (obj.get_fenotipo()))

    def __gt__(self, obj):
        return ((self.get_fenotipo()) > (obj.get_fenotipo()))

    def __le__(self, obj):
        return ((self.get_fenotipo()) <= (obj.get_fenotipo()))

    def __ge__(self, obj):
        return ((self.get_fenotipo()) >= (obj.get_fenotipo()))

```

```
def __eq__(self, obj):
    return (self.get_fenotipo() == obj.get_fenotipo())
```

## 1.2 População

```
[39]: class Populacao():
    def __init__(self,
        quant_pais: int,
        fn_objetivo: Callable[..., float],
        fabric_fn_mutacao: Callable[[float], Callable[[List[float]],
↪List[float]]],
        quant_parametros_fn_objetivo: int = 1,
        is_minimization: bool = True,
        lim_inf: List[float] = [-math.inf],
        lim_sup: List[float] = [math.inf],
        quant_filhos: int = -1,
        constrains: List[Callable[[List[float]], bool]] = []
    ):
        self.individuos: List[Individuo] = []
        for _ in range(quant_pais):
            genotipo: List[float] = [rd.uniform(
                lim_inf[i], lim_sup[i]) for i in
↪range(quant_parametros_fn_objetivo)]

            novo_individuo = Individuo(genotipo=genotipo,
                                       fn_objetivo=fn_objetivo,
                                       fabric_fn_mutacao=fabric_fn_mutacao,
                                       is_minimization=is_minimization,
                                       constrains=constrains
                                       )
            self.individuos.append(novo_individuo)

        self.__quant_pais = quant_pais
        self.__quant_filhos = quant_filhos if quant_filhos > 0 else quant_pais
        self.is_minimization = is_minimization
        self.quant_geracoes = 0

    def sexo_descontrolado_sozinho(self):
        """
        Realiza reprodução assexuada de indivíduos selecionados aleatoriamente.

        Esta função seleciona aleatoriamente um indivíduo existente na
↪população e realiza
        a reprodução assexuada do mesmo para gerar um número específico de
↪filhos. Os filhos
```

*são adicionados à população existente.*

*Parâmetros:*

*- self: A instância da classe que invoca o método.*

*Retorna:*

*- Nenhum valor de retorno.*

*Mutações no estado do objeto:*

*- A lista de indivíduos é ampliada para incluir os novos filhos.*

*"""*

```
filhos: List[Individuo] = []
```

```
for _ in range(self.__quant_filhos):
```

```
    pai = self.individuos[rd.randint(0, len(self.individuos))]
```

```
    filhos.extend(pai.reproduzir_assexuado())
```

```
self.individuos.extend(filhos)
```

```
def sexo_descontrolado(self):
```

```
    """
```

*Realiza reprodução sexuada de indivíduos selecionados aleatoriamente.*

*Esta função seleciona aleatoriamente dois indivíduos existentes na*  
↪ *população e realiza*

*a reprodução sexuada dos mesmos para gerar um número específico de*  
↪ *filhos. Os filhos*

*são adicionados à população existente.*

*Parâmetros:*

*- self: A instância da classe que invoca o método.*

*Retorna:*

*- Nenhum valor de retorno.*

*Mutações no estado do objeto:*

*- A lista de indivíduos é ampliada para incluir os novos filhos.*

*"""*

```
filhos: List[Individuo] = []
```

```
for _ in range(self.__quant_filhos):
```

```
    pai = self.individuos[rd.randint(0, len(self.individuos))]
```

```
    mae = self.individuos[rd.randint(0, len(self.individuos))]
```

```
    filhos.extend(mae.reproduzir_sexuado(pai))
```

```
self.individuos.extend(filhos)
```

```
def matar_os_fracos(self):
```

```
    """
```

*Remove os indivíduos mais fracos da população.*

A função ordena a lista de indivíduos e remove os indivíduos mais  
↪fracos,  
mantendo apenas os melhores indivíduos de acordo com a quantidade de  
↪pais  
definida.

Se a função de avaliação for de minimização, os primeiros self.  
↪\_\_quant\_pais  
indivíduos da lista ordenada (por fenótipo) são selecionados, caso  
↪contrário,  
o mesmo acontecerá pegando do final da lista.

Parâmetros:

- self: referência ao objeto da classe

Retorno:

- None

Mutações no estado do objeto:

- A lista de indivíduos é reduzida para o tamanho original de modo a  
conter apenas os melhores indivíduos dessa geração.

"""

```
self.individuos.sort(reverse=not self.is_minimization)
self.individuos = self.individuos[:self.__quant_pais]
```

```
def melhor_individuo(self) -> Indivíduo:
    return sorted(self.individuos)[0] if self.is_minimization else
↪sorted(self.individuos)[-1]
```

```
def individuo_medio(self) -> Indivíduo:
    return sorted(self.individuos)[math.floor(self.__quant_pais / 2)]
```

```
def selecionar_melhor(self, individuos: List[Indivíduo]) -> Indivíduo:
    return sorted(individuos)[0] if self.is_minimization else
↪sorted(individuos)[-1]
```

```
def selecionar_medio(self, individuos: List[Indivíduo]) -> Indivíduo:
    return sorted(individuos)[math.floor(len(individuos) / 2)]
```

```
def __str__(self):
    r = "População:\n"
    for individuo in self.individuos:
        r += individuo.__str__() + ", "
    return r
```

## 2 Problema 1:

maximizar  $f(x) = x \sin 10x + 1$   
sujeito a:  $-1 \leq x \leq 2$

### 2.1 Gerando população

```
[40]: def evoluir(quantidade_geracoes: int, pop: Populacao) -> Tuple[Individuo,
↳Individuo]:
    melhores_de_cada_geracao: List[Individuo] = []
    pau_medio: List[Individuo] = []

    for _ in range(quantidade_geracoes):
        pop.sexo_descontrolado_sozinho()
        pop.matar_os_fracos()
        melhores_de_cada_geracao.append(pop.melhor_individuo())
        pau_medio.append(pop.individuo_medio())

    return (pop.selecionar_melhor(melhores_de_cada_geracao), pop.
↳selecionar_medio(pau_medio))

def fabric_fn_mutacao(mutation_rate: float) -> Callable:
    def fn_mutacao(genotipo: List[float]) -> List[float]:
        return [g + rd.uniform(-mutation_rate, mutation_rate) for g in genotipo]
    return fn_mutacao

def new_exp(quant_pais: int = 100, quant_filhos: int = 100) -> Populacao:

    return Populacao(quant_pais=quant_pais,
                      quant_filhos=quant_filhos,
                      fn_objetivo=(lambda x: x*np.sin(10*3.14*x) + 1),
                      fabric_fn_mutacao=fabric_fn_mutacao,
                      is_minimization=False,
                      lim_inf=[-1], lim_sup=[2]
                      )

# Assuming evoluir function and new_exp function are defined correctly

results: List[Tuple[int, int, int, Tuple[Individuo, Individuo]]] = []
for quantidade_geracoes in range(10, 110, 10):
    for quant_pais in range(10, 110, 10):
        for quant_filhos in range(10, 110, 10):
            pop = new_exp(quant_pais, quant_filhos) # Create the population
            # Evolve and get the best and average
```

```

best, avg = evoluir(quantidade_geracoes, pop)
# Append the results with the structure including the parameters
results.append(
    (quantidade_geracoes, quant_pais, quant_filhos, (best, avg)))

```

## 2.2 Mostrando tabela solicitada

```

[58]: from tabulate import tabulate

data = []

for entry in results:
    quantidade_geracoes, quant_pais, quant_filhos, (
        best_individuo, avg_individuo) = entry
    row = [
        quantidade_geracoes, # Number of generations
        quant_pais, # Number of parents
        quant_filhos, # Number of children
        best_individuo.genotipo[0], # list of parameters of the best individuo
        best_individuo.get_fenotipo(), # f(x) of the best individuo
        avg_individuo.genotipo[0], # list of parameters of the average
        ↪ individuo
        avg_individuo.get_fenotipo(), # f(x) of the average individuo
    ]
    data.append(row)

# Define headers for your new columns
headers = ["tmax", " ", " ", "best x",
           "best f(x)", "avg x", "avg f(x)"]

# Print the table using tabulate
table = tabulate(data,
                 headers=headers,
                 tablefmt="github",
                 floatfmt=".4f"
                 )
print(table)

```

Generations	Parents	Children	Best Fitness parameters	Average Fitness y
10	10	1.38	[-0.171733395064647,	[-0.22478350635238714,
0.03733889001102848]		4.82		
0.23281747715567136]				



10	10	20	[0.6783311773472522,
0.46030019750713014]		0.10	[0.5391643295888559,
0.3066902130328002]		0.24	
10	10	30	[0.30803673668093545,
0.12609057005913055]		0.58	[0.015444113547094046,
-0.006292684555863556]		0.97	
10	10	40	[0.686364251173786,
0.47232449280768357]		0.10	[0.6115700035938361,
0.3524400635975502]		0.20	
10	10	50	[0.8423743445580424,
0.7152535606611893]		0.03	[0.7294780517328971,
0.5331878943443521]		0.07	
10	10	60	[0.78786122482146,
0.6167789388718151]		0.05	[0.6626775541578904,
0.41137974041309855]		0.19	
10	10	70	[0.6375916054451569,
0.40221467344803047]		0.13	[0.33174095613464133,
0.12402451495541304]		0.47	
10	10	80	[0.8201298400357417,
0.6767807517941595]		0.03	[0.7379435981267501,
0.5235547983845348]		0.11	
10	10	90	[0.7644514405006324,
0.5763374977194266]		0.06	[0.5042525802400439,
0.23514775924805026]		0.28	
10	10	100	[0.6432922399502645,
0.405488274468484]		0.13	[0.3406356532456632,
0.11665909853890852]		0.43	
10	20	10	[-0.24750247744341564,
0.05927256232612252]		1.56	[-0.4865463497924982,
0.11141729323613385]		3.78	
10	20	20	[0.729488708157408,
0.5243172348134847]		0.08	[0.5091598056899477,
0.33178293832239636]		0.77	
10	20	30	[0.8227475309466736,
0.6819904934421256]		0.03	[0.6293855150358549,
0.42715114848554525]		0.23	
10	20	40	[0.8154739869357593,
0.6577276957445454]		0.04	[0.678929740988247,
0.4343569862746779]		0.17	
10	20	50	[0.5358380042900124,
0.2750183143059065]		0.23	[0.18701291947661966,
0.023855101974879875]		0.67	
10	20	60	[0.8245703912575322,
0.6747367572531837]		0.03	[0.5629893627234389,
0.29269223141398726]		0.25	
10	20	70	[0.7011420432596599,
0.4780387096138759]		0.11	[0.4885148718184622,
0.22517114093789167]		0.28	

10	20	80   [0.849020126922891,
0.7212958151577846]		0.02   [0.6433723006688113,
0.4168505250452574]		0.13
10	20	90   [0.8672644788802231,
0.7386348793937968]		0.04   [0.7276087313100904,
0.5516593879258775]		0.12
10	20	100   [0.5676245222051832,
0.32218263605240416]		0.19   [0.34043256391242516,
0.10687518331616373]		0.44
10	30	10   [0.09866243435407794,
0.002204468322217351]		0.82   [-0.46963442815001677,
-0.0468947814263371]		9.31
10	30	20   [0.5616580363100062,
0.3214674382797631]		0.20   [0.24569341685073443,
-0.074709832485842]		2.39
10	30	30   [0.30025395121104853,
0.07591764062300228]		0.51   [-0.0667873284957946,
-0.02226332321617007]		1.21
10	30	40   [0.4341260294317849,
0.18596473120159662]		0.32   [0.14783858575923725,
-0.01914770182206793]		0.89
10	30	50   [0.8570418200660288,
0.7466414121855307]		0.04   [0.2394777022448253,
0.06042393332970514]		0.58
10	30	60   [0.6276457976413861,
0.3847516377664519]		0.15   [0.4966607421046053,
0.19366839085603726]		0.53
10	30	70   [0.8281153177276246,
0.6841074532350426]		0.03   [0.388399762380646,
0.14807665462744465]		0.37
10	30	80   [0.6942083645197891,
0.4797968265724403]		0.09   [0.5071483128701537,
0.2384333656226077]		0.28
10	30	90   [0.8866094225867643,
0.7769197036590132]		0.02   [0.6771735668261132,
0.44893869029912664]		0.11
10	30	100   [0.8612187154863263,
0.7407597867754758]		0.02   [0.665712595608442,
0.43877526278585777]		0.11
10	40	10   [-0.28249502895317113,
0.047100143818737866]		1.75   [-0.59755421133289,
0.17240897017254142]		5.96
10	40	20   [0.04695043617252051,
0.014274797085859076]		0.92   [-0.6087407537857826,
0.4174387002656722]		2.81
10	40	30   [0.5184251642695087,
0.27694799635233697]		0.24   [0.5396725007492278,
0.19271369173000938]		1.18

10	40	40   [0.8008510763090585,
0.6452312642986255]		0.04   [0.4910899856997625,
0.15665358780022154]		0.97
10	40	50   [0.787520778437123,
0.6344836627784864]		0.07   [0.02898862150510828,
-0.017507459604914385]		0.98
10	40	60   [0.8415160397069886,
0.705002611422358]		0.03   [0.4691399876121962,
0.21382500278780314]		0.29
10	40	70   [0.6989035065293382,
0.4777571768582133]		0.10   [0.4214364631462187,
0.21635214879969175]		0.48
10	40	80   [0.7361178542189234,
0.5566940193044306]		0.09   [0.4737318963362692,
0.2141412329774917]		0.29
10	40	90   [0.7099058643412566,
0.5039065169837046]		0.08   [0.5125407190025937,
0.2680768003921943]		0.24
10	40	100   [0.875771979000043,
0.7708743978029916]		0.02   [0.6451650394226757,
0.40718501041240346]		0.13
10	50	10   [-0.12342790787503301,
-0.004470356505227514]		1.30   [-0.17283425584222156,
-0.35598703970770995]		16.26
10	50	20   [0.5367803388795452,
0.31264142013353496]		0.27   [0.5093076174613382,
0.08894989328030194]		3.15
10	50	30   [0.5244348948404141,
0.2682022059538488]		0.23   [-0.45103499267146696,
0.20009538643226416]		2.11
10	50	40   [0.755549343482546,
0.5702020042447933]		0.06   [-0.005128946071441126,
0.1057731014413876]		2.13
10	50	50   [0.7247082464987976,
0.5012804099039172]		0.13   [-0.21071150846367998,
0.007676448312170514]		1.60
10	50	60   [0.7539107834312996,
0.5777374771519078]		0.07   [0.1051168803176421,
0.03081944532441036]		0.84
10	50	70   [0.8191904935285231,
0.6661392282239235]		0.04   [0.6716386350433243,
0.40345880471727874]		0.33
10	50	80   [0.6831901869136119,
0.4647098712724067]		0.10   [0.35330738717080756,
0.1379412917996977]		0.44
10	50	90   [0.8067226432711204,
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10	50	100   [0.6840489391976847,
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10	60	10   [0.2746799559231802,
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10	60	30   [0.031932524539319274,
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10	60	40   [0.5038344940291608,
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10	60	50   [0.6987953956514756,
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10	60	70   [0.5626809819635805,
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10	60	90   [0.7954955083272257,
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10	60	100   [0.788472557992234,
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10	70	10   [0.3442836371514166,
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10	70	20   [0.5295089743388851,
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10	70	30   [0.5893664617836032,
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10	70	40   [0.5309401441999454,
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10	70	50   [0.11447872817326796,
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10	70	90	[0.7750832792947419,
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10	80	10	[-0.09856404851711435,
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10	80	20	[0.3162526587349605,
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10	80	30	[0.18965545961324898,
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10	80	40	[0.16917924895536116,
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10	80	70	[0.8078914753574247,
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10	80	90	[0.7760912382726269,
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10	80	100	[0.7094906980694917,
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10	90	10	[0.724666403815033,
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10	90	20   [0.5418030263783787,
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10	90	30   [0.7783557579964926,
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10	90	40   [0.2212559875535648,
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10	90	50   [0.10813984056596582,
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10	90	60   [0.8363929361366718,
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10	90	70   [0.7854701502412486,
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10	90	90   [0.862248913331228,
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10	90	100   [0.6317429158341583,
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10	100	40   [0.5689487931905385,
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10	100	50   [0.5989505186470065,
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10	100	60   [0.8018349901380574,
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10	100	70   [0.7494041888883964,
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20   10	10   [0.2390876149734844,
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20   10	20   [0.4628839837180935,
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20   10	40   [0.856664035765151,
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20   10	50   [0.9504860415340077,
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20   10	70   [0.9268401763915584,
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20   10	80   [0.9378738112935876,
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20	80	50   [0.7285116429936895,
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20	80	60   [0.8361367898870701,
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20	80	70   [0.8760908785821522,
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20	80	90   [0.4688119442731943,
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20	90	10   [0.41130209966497777,
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20	90	20   [0.5851409179933932,
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20	90	40   [0.8100477274322229,
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20	90	60   [0.8282108949621194,
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20	90	70   [0.8049499806682036,
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20	90	80   [0.8316946247002933,
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20	90	90   [0.8400050191692746,
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20	100	20   [0.6119493141820488,
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30	20	40   [0.8991522500862041,
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30	20	50   [0.8916373658885507,
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90	20	70   [0.9916504476845347,
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0.7306606075707983]		0.02
100	30	70   [1.0039963903703133,
1.007773424646301]		0.00   [0.9986577350264394,
1.0027944027236333]		0.00
100	30	80   [0.999172600817541,
0.9979428903685635]		0.00   [0.9458817377286813,
0.8942226581038957]		0.00
100	30	90   [0.9998260272802701,
0.9995722919281992]		0.00   [0.9502043452320975,
0.9042421925933277]		0.00

100	30	100   [0.9944070334504997,
0.9888839880631337]		0.00   [0.9605806716234796,
0.9206062784517237]		0.00
100	40	10   [0.7520894095894721,
0.5496978641946503]		0.09   [0.3165880211050127,
0.13606786155715903]		0.60
100	40	20   [0.8546907368112678,
0.7271440138746026]		0.02   [0.5890630602949618,
0.3290013194232428]		0.20
100	40	30   [0.9722736936248857,
0.9456995519253097]		0.00   [0.7703039297527999,
0.600912643671979]		0.06
100	40	40   [0.9851294273303524,
0.9693953919047761]		0.00   [0.7961250572003371,
0.6467986937330715]		0.06
100	40	50   [1.0006135290367042,
1.0001994237808194]		0.00   [0.9158570931341901,
0.8459018544805174]		0.01
100	40	60   [0.9950842240207471,
0.9897077104099914]		0.00   [0.8764756782062941,
0.7831742870872835]		0.04
100	40	70   [0.9973972223358383,
0.9949829983480996]		0.00   [0.9099572723001488,
0.8212486221604929]		0.01
100	40	80   [1.0040072765316896,
1.0077387763032895]		0.00   [1.0176827580164651,
1.0416482594697678]		0.00
100	40	90   [0.9989832248930041,
0.9973832816543514]		0.00   [0.9826882212598035,
0.9689835330870428]		0.00
100	40	100   [0.9973283587242053,
0.9949039718202295]		0.00   [0.9542134807450369,
0.9103587255857668]		0.00
100	50	10   [0.8498916568340296,
0.7208077062816118]		0.02   [0.6998172685048287,
0.47222866280048564]		0.12
100	50	20   [0.815227912403153,
0.6667264996119923]		0.03   [0.6323825187764127,
0.41061134846062297]		0.15
100	50	30   [0.9247726737914859,
0.8513847573787043]		0.01   [0.6441784219432499,
0.41912661958925046]		0.13
100	50	40   [0.9240803372639808,
0.8557009964362227]		0.01   [0.6455799235811651,
0.41557805160960903]		0.13
100	50	50   [0.9878043646303242,
0.9763257873516842]		0.00   [0.8431199779550915,
0.7092182008704012]		0.02

100	50	60   [0.9993211132480576,
0.9980721555852267]		0.00   [0.8470207634015512,
0.7220698832227844]		0.03
100	50	70   [1.0059625787873256,
1.0116141064851272]		0.00   [0.8813859263790482,
0.7748709736288182]		0.01
100	50	80   [1.0031313008677052,
1.006013200413956]		0.00   [0.8798370706609036,
0.7762291864673334]		0.01
100	50	90   [1.0003148367844852,
1.000937908155472]		0.00   [0.884613357272707,
0.7837858882168517]		0.01
100	50	100   [0.9987423618308875,
0.9971582274796978]		0.00   [0.9737343695502604,
0.9546192646362273]		0.00
100	60	10   [0.7768738411537137,
0.5962678006224515]		0.06   [0.4475890427877225,
0.18868303872891967]		0.32
100	60	20   [0.965554952270816,
0.9308898312412284]		0.00   [0.7656967746248793,
0.6041365258483711]		0.09
100	60	30   [1.0028182392528509,
1.007896726366016]		0.00   [0.8253938139484249,
0.6641123735980703]		0.06
100	60	40   [0.9454979596572284,
0.898073175024382]		0.00   [0.6901405244700676,
0.48680341478479505]		0.11
100	60	50   [0.975571337315581,
0.9462247096918444]		0.00   [0.7233650826976291,
0.5144558083528091]		0.08
100	60	60   [0.9512015110576992,
0.9047265811320914]		0.00   [0.7687142493762432,
0.5701443105920251]		0.10
100	60	70   [1.0128425148040856,
1.0258558540217166]		0.00   [0.862949838737222,
0.753323565871895]		0.03
100	60	80   [0.9985851455850482,
0.9964022125835985]		0.00   [0.9153998777604357,
0.8484948018702249]		0.02
100	60	90   [0.9974555467573467,
0.9952449441258143]		0.00   [0.9321507679714531,
0.8742860959125298]		0.01
100	60	100   [0.9987742186092429,
0.9975280781532376]		0.00   [0.8878057045524052,
0.7853237576688631]		0.01
100	70	10   [0.6779119146246972,
0.46557875714080144]		0.11   [0.32224279150944146,
0.0871269011804316]		0.49

100	70	20   [0.9781829183172279,
0.9643118951551262]		0.01   [0.7730659493789518,
0.613528783419328]		0.08
100	70	30   [0.922071251158398,
0.8509979396856328]		0.01   [0.8268002329659958,
0.6635495003560172]		0.07
100	70	40   [0.992994112729736,
0.985731937999047]		0.00   [0.7637774861203577,
0.5737274637605982]		0.07
100	70	50   [0.9982027372942955,
0.9984061888564523]		0.00   [0.8313569870953201,
0.6824425175220843]		0.04
100	70	60   [0.9998866495419101,
0.9994463572317274]		0.00   [0.8199540770062469,
0.671122534886794]		0.03
100	70	70   [0.9911428555299365,
0.9814639615199421]		0.00   [0.8723115982136452,
0.7782938057066264]		0.05
100	70	80   [1.0002289560078212,
1.0006169641300775]		0.00   [0.8734001685589206,
0.7647360612074375]		0.02
100	70	90   [0.9998352353566059,
1.0000672249188074]		0.00   [0.9034777957337399,
0.8209765138432981]		0.01
100	70	100   [0.9995100736815747,
0.9992425612347391]		0.00   [0.8800656978479819,
0.7785345523859801]		0.02
100	80	10   [0.7686256332464989,
0.589234496931725]		0.05   [0.6314749098912245,
0.3671011149369916]		0.24
100	80	20   [0.8903112887787118,
0.7895120567044154]		0.01   [0.6341355589641392,
0.413294791254764]		0.15
100	80	30   [0.8995155737777881,
0.8098170247075123]		0.01   [0.7047752448772702,
0.4880699481090672]		0.09
100	80	40   [0.9320728714017877,
0.8671330753728208]		0.00   [0.7684508268628999,
0.5870062847733628]		0.05
100	80	50   [0.9867552560253454,
0.9773466306877585]		0.00   [0.8010352837340161,
0.6296867912749406]		0.05
100	80	60   [0.9924218979636408,
0.9846191916907082]		0.00   [0.8791219339371172,
0.7603176233863848]		0.03
100	80	70   [0.998652379632427,
0.9979296090050108]		0.00   [0.8752482637983898,
0.7650110532521337]		0.02

100	80	80	[1.0016772450222158,
1.0027574896449378]			0.00   [0.8414285581483812,
0.7027223274205666]			0.03
100	80	90	[1.0013754878366778,
1.0028597018364243]			0.00   [0.91179180905255,
0.8183733847002956]			0.02
100	80	100	[0.9960679541784336,
0.9914854730930445]			0.00   [0.9177825283520086,
0.837841888627278]			0.01
100	90	10	[0.6279108479173656,
0.3866199685779454]			0.14   [0.11495753225927133,
0.029226445357896716]			0.81
100	90	20	[0.6736784682568768,
0.4398666546555766]			0.13   [0.37093735847099985,
0.17282815993006218]			0.52
100	90	30	[0.9609345068943628,
0.9285075850725877]			0.00   [0.565245978924505,
0.31521402705278656]			0.19
100	90	40	[1.0033891080785597,
1.004064327440778]			0.00   [0.8216780947323011,
0.6489747368524408]			0.10
100	90	50	[0.9482191839487072,
0.898555471376448]			0.00   [0.7319613152250102,
0.5446571579269797]			0.08
100	90	60	[0.9978326950055143,
0.994794302499483]			0.00   [0.8696299562143414,
0.7664230250424126]			0.03
100	90	70	[0.9953732854920867,
0.9898125988956472]			0.00   [0.7277291187742265,
0.5287168526409541]			0.07
100	90	80	[1.0021637675435116,
1.004535364618742]			0.00   [0.8519502644382198,
0.7244809673839528]			0.02
100	90	90	[0.9946807768604384,
0.9897137154525606]			0.00   [0.8068900077865051,
0.6453809831038851]			0.04
100	90	100	[1.0026316321241953,
1.0048122304380271]			0.00   [0.852817300722377,
0.731760814163159]			0.02
100	100	10	[0.6726377422099128,
0.4537913600149143]			0.11   [-0.0511164629540605,
0.03817947465771245]			1.23
100	100	20	[0.8664949678194949,
0.746506661110206]			0.02   [0.651292012741309,
0.4324184265984955]			0.13
100	100	30	[0.7660022061717031,
0.5918065960435497]			0.06   [0.3451279399009913,
0.1222538849294941]			0.43

	100		100		40		[0.9605205624614013,
0.9268157033666179]					0.00		[0.6719483138536262,
0.44780063203420967]					0.11		
	100		100		50		[0.9923793513935297,
0.9850178418003457]					0.00		[0.7885735228125028,
0.6331807310479776]					0.06		
	100		100		60		[0.9785053588782779,
0.9567198482639553]					0.00		[0.7589994626410388,
0.580761206173516]					0.06		
	100		100		70		[0.9971932037186793,
0.994694132519617]					0.00		[0.7971859422130233,
0.6368452639309039]					0.04		
	100		100		80		[0.9983541427497263,
0.9956881132974298]					0.00		[0.7752568181209216,
0.5999176656521418]					0.05		
	100		100		90		[1.0000800893954858,
1.00037859650579]					0.00		[0.8687646499609998,
0.7626051086342827]					0.02		
	100		100		100		[1.000798589523461,
1.0009671428596905]					0.00		[0.8888904798539382,
0.8008975497232838]					0.02		

## 2.3 Plotando

### 2.3.1 Criando o data frame

```
[42]: import pandas as pd

data = []

for (quantidade_geracoes, quant_pais, quant_filhos, (best_individuo,
↳ avg_individuo)) in results:
    data.append({
        'Quantidade Gerações': quantidade_geracoes,
        'Quant Pais': quant_pais,
        'Quant Filhos': quant_filhos,
        # Assuming this is accessible and meaningful (e.g., a list or tuple of
↳ parameters)
        'Best Genotipo': best_individuo.genotipo,
        'Best Fitness': best_individuo.get_fenotipo(),
        # Similarly, assuming this is a list or tuple
        'Average Genotipo': avg_individuo.genotipo,
        'Average Fitness': avg_individuo.get_fenotipo()
    })

df = pd.DataFrame(data)

df[['Best x']] = pd.DataFrame(
```

```

df['Best Genotipo'].tolist(), index=df.index)

df[['Avg x']] = pd.DataFrame(
    df['Average Genotipo'].tolist(), index=df.index)

df.drop(['Best Genotipo', 'Average Genotipo'], axis=1, inplace=True)

# Display the first few rows to verify
print(df.head())

```

	Quantidade Gerações	Quant Pais	Quant Filhos	Best Fitness \
0	10	10	10	2.639363
1	10	10	20	2.643977
2	10	10	30	2.050991
3	10	10	40	2.851208
4	10	10	50	2.851211

	Average Fitness	Best x	Avg x
0	2.002990	1.655253	-1.061123
1	2.472002	1.648482	1.636438
2	2.040169	-1.051282	-1.056065
3	2.835102	1.851557	1.855686
4	2.829108	1.851528	1.856407

### 2.3.2 Plotando o gráfico

```

[43]: import numpy as np
import matplotlib.pyplot as plt
from scipy.optimize import minimize_scalar

def fn_objetivo(x): return x * np.sin(10 * 3.14 * x) + 1

resultado = minimize_scalar(
    lambda x: -fn_objetivo(x), bounds=(-1, 2), method='bounded')

ponto_maximo = resultado.x
valor_maximo = fn_objetivo(ponto_maximo)

x = np.linspace(-1, 2, 400)
y = fn_objetivo(x)

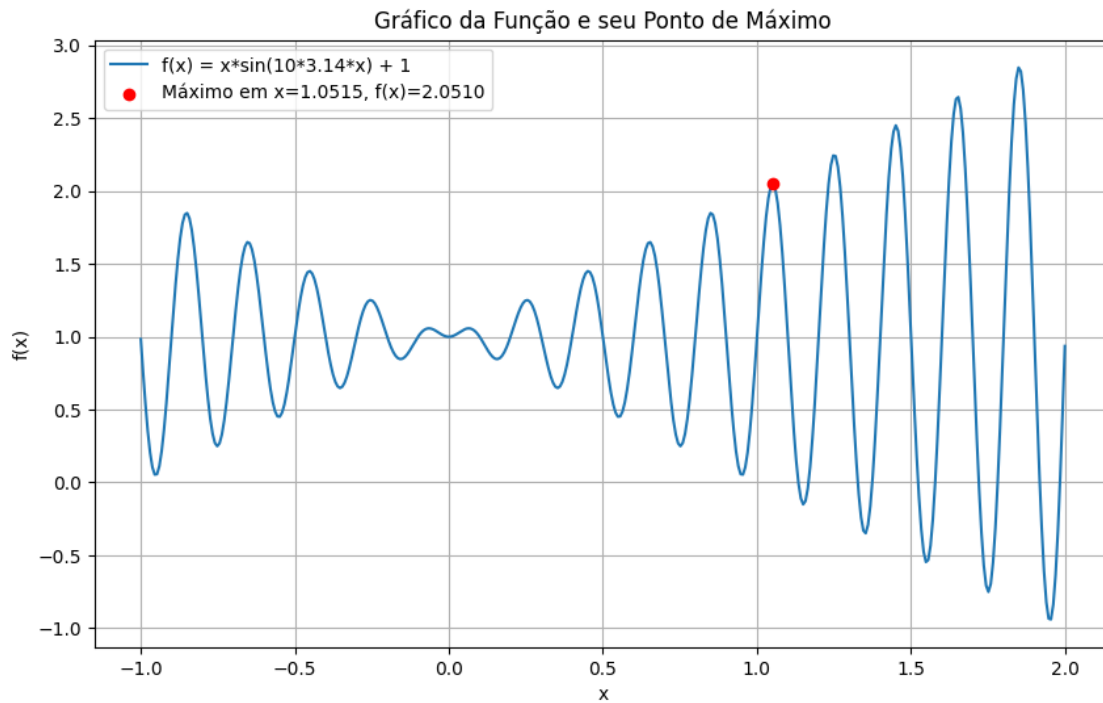
plt.figure(figsize=(10, 6))
plt.plot(x, y, label='f(x) = x*sin(10*3.14*x) + 1')
plt.scatter(ponto_maximo, valor_maximo, color='red', zorder=5,
            label=f'Máximo em x={ponto_maximo:.4f}, f(x)={valor_maximo:.4f}')

```



```
plt.title('Gráfico da Função e seu Ponto de Máximo')
plt.xlabel('x')
plt.ylabel('f(x)')
plt.legend()
plt.grid(True)

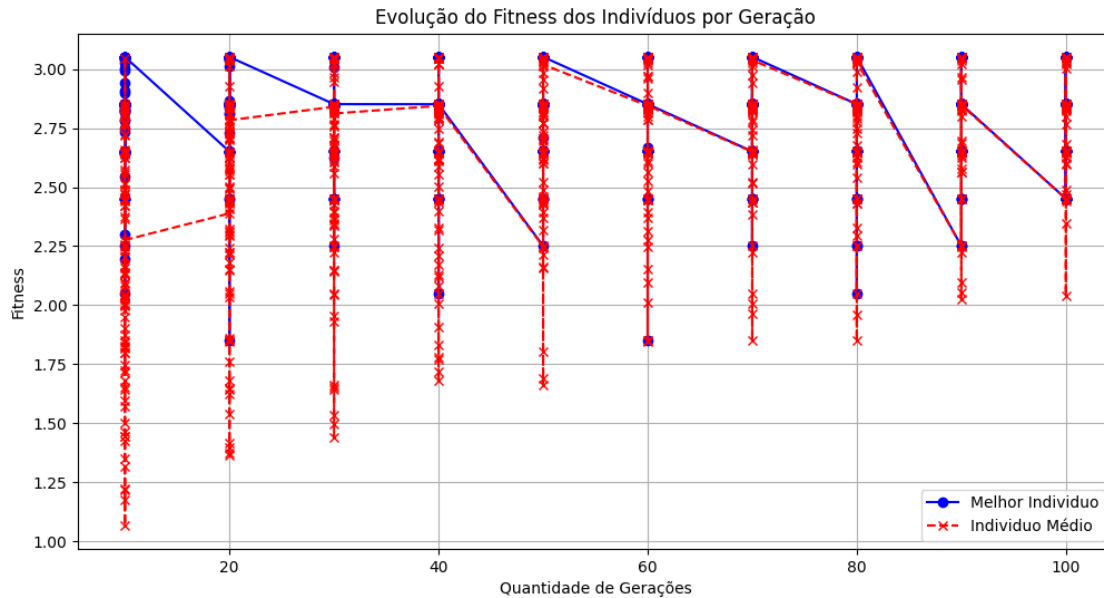
plt.show()
```



```
[44]: import matplotlib.pyplot as plt

# Adjusting the plotting code to use the correct column names
plt.figure(figsize=(12, 6))
plt.plot(df['Quantidade Gerações'], df['Best Fitness'],
         label='Melhor Indivíduo', marker='o', linestyle='-', color='blue')
plt.plot(df['Quantidade Gerações'], df['Average Fitness'],
         label='Indivíduo Médio', marker='x', linestyle='--', color='red')

plt.title('Evolução do Fitness dos Indivíduos por Geração')
plt.xlabel('Quantidade de Gerações')
plt.ylabel('Fitness')
plt.legend()
plt.grid(True)
plt.show()
```



### 3 Problema 2

maximizar  $f(x, y) = (1 - x)^2 + 100(y - x^2)^2$

sujeito a:

$$(x - 1)^3 - y + 1 < 0$$

$$x + y - 2 \leq 0$$

$$-1.5 \leq x \leq 1.5$$

$$-0.5 \leq y \leq 2.5$$

#### 3.1 Gerando a população

```
[45]: def new_exp(quant_pais: int = 100, quant_filhos: int = 100) -> Populacao:
    return Populacao(
        quant_pais=quant_pais,
        fn_objetivo=(lambda x, y: (1-x)**2 + 100*(y-x**2)**2),
        fabric_fn_mutacao=fabric_fn_mutacao,
        quant_parametros_fn_objetivo=2,
        is_minimization=True,
        lim_inf=[-1.5, -.5],
        lim_sup=[1.5, .5],
        quant_filhos=quant_filhos,
        constrains=[(lambda x, y: ((x-1)**3 - y + 1) <= 0), (lambda x, y: (x +
        y - 2) <= 0)]
    )

results: List[Tuple[int, int, int, Tuple[Individuo, Individuo]]] = []
```

```

for quantidade_geracoes in range(10, 110, 10):
    for quant_pais in range(10, 110, 10):
        for quant_filhos in range(10, 110, 10):
            pop = new_exp(quant_pais, quant_filhos) # Create the population
            # Evolve and get the best and average
            best, avg = evoluir(quantidade_geracoes, pop)
            # Append the results with the structure including the parameters
            results.append(
                (quantidade_geracoes, quant_pais, quant_filhos, (best, avg)))

```

### 3.2 Mostrando tabela solicitada

```

[64]: from tabulate import tabulate

data = []

for entry in results:
    quantidade_geracoes, quant_pais, quant_filhos, (
        best_individuo, avg_individuo) = entry
    row = [
        quantidade_geracoes, # Number of generations
        quant_pais,           # Number of parents
        quant_filhos,         # Number of children
        best_individuo.genotipo[0], # list of parameters of the best individuo
        best_individuo.genotipo[1], # list of parameters of the best individuo
        best_individuo.get_fenotipo(), # f(x) of the best individuo
        avg_individuo.genotipo[0], # list of parameters of the average
        ↪ individuo
        avg_individuo.genotipo[1], # list of parameters of the average
        ↪ individuo
        avg_individuo.get_fenotipo(), # f(x) of the average individuo
    ]
    data.append(row)

# Define headers for your new columns
headers = ["tmax", " ", " ", "best x", "best y",
           "best f(x,y)", "avg x", "avg y", "avg f(x,y)"]

# Print the table using tabulate
table = tabulate(data,
                  headers=headers,
                  tablefmt="github",
                  floatfmt=".4f"
                  )
print(table)

```

tmax			best x	best y	best f(x,y)	avg x	avg y
------	--	--	--------	--------	-------------	-------	-------

```

avg f(x,y) |
|-----|-----|-----|-----|-----|-----|-----|-----|
|-----|
|      10 | 10 | 10 | -0.1717 | 0.0373 |      1.3791 | -0.2248 | 0.2328 |
4.8231 |
|      10 | 10 | 20 | 0.6783 | 0.4603 |      0.1035 | 0.5392 | 0.3067 |
0.2379 |
|      10 | 10 | 30 | 0.3080 | 0.1261 |      0.5762 | 0.0154 | -0.0063 |
0.9736 |
|      10 | 10 | 40 | 0.6864 | 0.4723 |      0.0985 | 0.6116 | 0.3524 |
0.1974 |
|      10 | 10 | 50 | 0.8424 | 0.7153 |      0.0280 | 0.7295 | 0.5332 |
0.0733 |
|      10 | 10 | 60 | 0.7879 | 0.6168 |      0.0466 | 0.6627 | 0.4114 |
0.1909 |
|      10 | 10 | 70 | 0.6376 | 0.4022 |      0.1332 | 0.3317 | 0.1240 |
0.4661 |
|      10 | 10 | 80 | 0.8201 | 0.6768 |      0.0341 | 0.7379 | 0.5236 |
0.1128 |
|      10 | 10 | 90 | 0.7645 | 0.5763 |      0.0620 | 0.5043 | 0.2351 |
0.2823 |
|      10 | 10 | 100 | 0.6433 | 0.4055 |      0.1342 | 0.3406 | 0.1167 |
0.4348 |
|      10 | 20 | 10 | -0.2475 | 0.0593 |      1.5567 | -0.4865 | 0.1114 |
3.7801 |
|      10 | 20 | 20 | 0.7295 | 0.5243 |      0.0793 | 0.5092 | 0.3318 |
0.7671 |
|      10 | 20 | 30 | 0.8227 | 0.6820 |      0.0340 | 0.6294 | 0.4272 |
0.2336 |
|      10 | 20 | 40 | 0.8155 | 0.6577 |      0.0393 | 0.6789 | 0.4344 |
0.1738 |
|      10 | 20 | 50 | 0.5358 | 0.2750 |      0.2301 | 0.1870 | 0.0239 |
0.6733 |
|      10 | 20 | 60 | 0.8246 | 0.6747 |      0.0335 | 0.5630 | 0.2927 |
0.2499 |
|      10 | 20 | 70 | 0.7011 | 0.4780 |      0.1077 | 0.4885 | 0.2252 |
0.2798 |
|      10 | 20 | 80 | 0.8490 | 0.7213 |      0.0228 | 0.6434 | 0.4169 |
0.1280 |
|      10 | 20 | 90 | 0.8673 | 0.7386 |      0.0359 | 0.7276 | 0.5517 |
0.1237 |
|      10 | 20 | 100 | 0.5676 | 0.3222 |      0.1869 | 0.3404 | 0.1069 |
0.4432 |
|      10 | 30 | 10 | 0.0987 | 0.0022 |      0.8181 | -0.4696 | -0.0469 |
9.3128 |
|      10 | 30 | 20 | 0.5617 | 0.3215 |      0.1958 | 0.2457 | -0.0747 |
2.3935 |
|      10 | 30 | 30 | 0.3003 | 0.0759 |      0.5099 | -0.0668 | -0.0223 |

```

1.2095									
10   30   40   0.4341   0.1860   0.3208   0.1478   -0.0191									
0.8943									
10   30   50   0.8570   0.7466   0.0351   0.2395   0.0604									
0.5793									
10   30   60   0.6276   0.3848   0.1471   0.4967   0.1937									
0.5343									
10   30   70   0.8281   0.6841   0.0298   0.3884   0.1481									
0.3748									
10   30   80   0.6942   0.4798   0.0940   0.5071   0.2384									
0.2781									
10   30   90   0.8866   0.7769   0.0212   0.6772   0.4489									
0.1135									
10   30   100   0.8612   0.7408   0.0193   0.6657   0.4388									
0.1137									
10   40   10   -0.2825   0.0471   1.7517   -0.5976   0.1724									
5.9622									
10   40   20   0.0470   0.0143   0.9229   -0.6087   0.4174									
2.8078									
10   40   30   0.5184   0.2769   0.2386   0.5397   0.1927									
1.1828									
10   40   40   0.8009   0.6452   0.0412   0.4911   0.1567									
0.9733									
10   40   50   0.7875   0.6345   0.0656   0.0290   -0.0175									
0.9765									
10   40   60   0.8415   0.7050   0.0261   0.4691   0.2138									
0.2857									
10   40   70   0.6989   0.4778   0.1021   0.4214   0.2164									
0.4848									
10   40   80   0.7361   0.5567   0.0916   0.4737   0.2141									
0.2875									
10   40   90   0.7099   0.5039   0.0842   0.5125   0.2681									
0.2405									
10   40   100   0.8758   0.7709   0.0170   0.6452   0.4072									
0.1341									
10   50   10   -0.1234   -0.0045   1.3009   -0.1728   -0.3560									
16.2642									
10   50   20   0.5368   0.3126   0.2746   0.5093   0.0889									
3.1459									
10   50   30   0.5244   0.2682   0.2308   -0.4510   0.2001									
2.1066									
10   50   40   0.7555   0.5702   0.0598   -0.0051   0.1058									
2.1285									
10   50   50   0.7247   0.5013   0.1330   -0.2107   0.0077									
1.6007									
10   50   60   0.7539   0.5777   0.0693   0.1051   0.0308									
0.8399									
10   50   70   0.8192   0.6661   0.0351   0.6716   0.4035									

0.3348									
10	50	80	0.6832	0.4647	0.1008	0.3533	0.1379		
0.4354									
10	50	90	0.8067	0.6409	0.0471	0.5876	0.3445		
0.1701									
10	50	100	0.6840	0.4583	0.1090	0.4492	0.2317		
0.3926									
10	60	10	0.2747	0.0890	0.5445	-0.4692	-0.2843		
27.6001									
10	60	20	0.3865	0.1622	0.3930	-0.4955	0.1588		
2.9897									
10	60	30	0.0319	0.0136	0.9529	-0.4383	0.2744		
2.7449									
10	60	40	0.5038	0.2511	0.2469	-0.5550	0.2898		
2.4509									
10	60	50	0.6988	0.4879	0.0907	0.0092	0.0886		
1.7659									
10	60	60	0.8398	0.7107	0.0287	0.6730	0.5336		
0.7563									
10	60	70	0.5627	0.3253	0.1988	0.2301	0.0931		
0.7537									
10	60	80	0.8184	0.6739	0.0347	0.1106	0.0547		
0.9712									
10	60	90	0.7955	0.6285	0.0437	0.3763	0.1264		
0.4120									
10	60	100	0.7885	0.6286	0.0495	0.6932	0.5112		
0.1885									
10	70	10	0.3443	0.0789	0.5871	-0.8778	0.2748		
28.0914									
10	70	20	0.5295	0.2619	0.2556	-0.1942	0.3270		
9.7947									
10	70	30	0.5894	0.3401	0.1739	-0.1369	0.1275		
2.4748									
10	70	40	0.5309	0.2770	0.2224	0.3871	0.2803		
2.0787									
10	70	50	0.1145	0.0213	0.7909	-0.1787	0.0109		
1.4336									
10	70	60	0.3801	0.1696	0.4477	-0.1624	-0.0518		
1.9627									
10	70	70	0.6443	0.3947	0.1680	0.2001	-0.0368		
1.2309									
10	70	80	0.7791	0.5925	0.0698	0.3593	0.0940		
0.5340									
10	70	90	0.7751	0.5956	0.0532	0.6890	0.5488		
0.6466									
10	70	100	0.8435	0.7078	0.0258	0.3197	0.1395		
0.6023									
10	80	10	-0.0986	-0.0364	1.4197	-0.4971	-0.4657		

53.0513									
10   80   20   0.3163   0.0697   0.5593   -0.3448   -0.1357									
8.2889									
10   80   30   0.1897   0.0870   0.9172   -0.2757   -0.0097									
2.3621									
10   80   40   0.1692   0.0217   0.6950   -0.3018   0.1921									
2.7147									
10   80   50   0.3610   0.1399   0.4175   -0.5014   0.2507									
2.2543									
10   80   60   0.7914   0.6158   0.0545   -0.1662   0.0786									
1.6204									
10   80   70   0.8079   0.6621   0.0458   0.0419   -0.0828									
1.6331									
10   80   80   0.4894   0.2356   0.2623   -0.2870   0.1072									
1.7183									
10   80   90   0.7761   0.6094   0.0552   -0.0932   -0.0078									
1.2223									
10   80   100   0.7095   0.5119   0.0917   0.5514   0.3681									
0.6118									
10   90   10   0.7247   0.5194   0.0791   1.0010   0.3855									
37.9996									
10   90   20   0.5418   0.3242   0.3042   -0.0521   0.2514									
7.2900									
10   90   30   0.7784   0.5802   0.1148   -0.0864   -0.1992									
5.4493									
10   90   40   0.2213   0.0205   0.6875   -0.0181   -0.1479									
3.2345									
10   90   50   0.1081   0.0114   0.7954   -0.4870   0.2680									
2.3061									
10   90   60   0.8364   0.7219   0.0766   -0.2441   0.0133									
1.7619									
10   90   70   0.7855   0.6264   0.0550   0.0029   -0.0860									
1.7342									
10   90   80   0.7699   0.5993   0.0571   -0.1747   0.0247									
1.3834									
10   90   90   0.8622   0.7383   0.0216   0.0263   -0.0437									
1.1453									
10   90   100   0.6317   0.3978   0.1358   0.0553   0.0362									
1.0024									
10   100   10   0.3314   0.1479   0.5923   -0.6315   -0.1646									
34.4093									
10   100   20   0.4620   0.2605   0.5103   0.7302   0.1469									
14.9936									
10   100   30   0.3956   0.1849   0.4461   -0.4365   0.3658									
5.1358									
10   100   40   0.5689   0.3217   0.1862   -0.1329   -0.1638									
4.5777									
10   100   50   0.5990   0.3512   0.1665   -0.2725   0.2319									

4.1042									
10   100   60   0.8018   0.6340   0.0473   -0.3370   0.0657									
2.0169									
10   100   70   0.7494   0.5593   0.0633   -0.5574   0.3295									
2.4611									
10   100   80   0.8394   0.7028   0.0261   0.0409   0.0577									
1.2341									
10   100   90   0.7726   0.5769   0.0915   -0.2740   0.0822									
1.6281									
10   100   100   0.6373   0.3895   0.1596   0.1713   -0.0184									
0.9144									
20   10   10   0.2391   0.0666   0.5878   -0.0497   -0.0194									
1.1498									
20   10   20   0.4629   0.1910   0.3426   0.0011   -0.0129									
1.0143									
20   10   30   0.7140   0.5065   0.0829   0.5222   0.2842									
0.2415									
20   10   40   0.8567   0.7375   0.0219   0.7614   0.5710									
0.0647									
20   10   50   0.9505   0.9054   0.0028   0.7502   0.5737									
0.0741									
20   10   60   0.8270   0.6850   0.0301   0.5519   0.2936									
0.2130									
20   10   70   0.9268   0.8566   0.0060   0.8215   0.6713									
0.0331									
20   10   80   0.9379   0.8780   0.0041   0.7692   0.5760									
0.0778									
20   10   90   0.9761   0.9546   0.0009   0.5964   0.3569									
0.1630									
20   10   100   1.0014   1.0038   0.0001   0.9162   0.8290									
0.0180									
20   20   10   0.7203   0.5295   0.0898   0.5274   0.3185									
0.3858									
20   20   20   0.4659   0.2129   0.2870   0.0092   0.0204									
1.0230									
20   20   30   0.7884   0.6188   0.0456   0.6454   0.4286									
0.1403									
20   20   40   0.6877   0.4733   0.0975   0.2300   0.0606									
0.5988									
20   20   50   0.7193   0.5205   0.0797   0.4663   0.1878									
0.3726									
20   20   60   0.7536   0.5812   0.0784   0.3269   0.1107									
0.4546									
20   20   70   0.9271   0.8620   0.0059   0.7210   0.5031									
0.1058									
20   20   80   0.9914   0.9768   0.0039   0.8047   0.6493									
0.0385									
20   20   90   0.8696   0.7562   0.0170   0.6291   0.4018									



0.1412									
20	20	100	0.9181	0.8413	0.0070	0.6766	0.4663		
0.1118									
20	30	10	0.0261	0.0145	0.9677	-0.5049	0.2397		
2.2879									
20	30	20	0.6485	0.4202	0.1236	0.5845	0.2902		
0.4370									
20	30	30	0.7460	0.5545	0.0649	0.5814	0.3539		
0.2003									
20	30	40	0.7685	0.5840	0.0579	0.5112	0.2755		
0.2593									
20	30	50	0.7971	0.6368	0.0414	0.6273	0.3697		
0.1956									
20	30	60	0.9141	0.8361	0.0074	0.6622	0.4440		
0.1171									
20	30	70	0.8475	0.7152	0.0242	0.7160	0.4950		
0.1118									
20	30	80	0.8464	0.7148	0.0239	0.6809	0.4588		
0.1042									
20	30	90	0.9532	0.9082	0.0022	0.7770	0.6071		
0.0509									
20	30	100	0.8702	0.7623	0.0194	0.5993	0.3560		
0.1616									
20	40	10	0.8315	0.6846	0.0330	-0.4067	0.1842		
2.0142									
20	40	20	0.7640	0.5734	0.0665	0.7423	0.4843		
0.5111									
20	40	30	0.6570	0.4208	0.1295	0.3811	0.1867		
0.5551									
20	40	40	0.8842	0.7805	0.0136	0.6371	0.3853		
0.1738									
20	40	50	0.6946	0.4669	0.1177	0.4973	0.2178		
0.3397									
20	40	60	0.7868	0.6153	0.0468	0.5924	0.3333		
0.1973									
20	40	70	0.8107	0.6572	0.0358	0.6725	0.4658		
0.1255									
20	40	80	0.7173	0.5078	0.0844	0.4903	0.2245		
0.2851									
20	40	90	0.9020	0.8117	0.0100	0.7198	0.5035		
0.0996									
20	40	100	0.8269	0.6741	0.0394	0.6173	0.4014		
0.1878									
20	50	10	0.2485	0.0510	0.5763	0.3485	-0.1003		
5.3402									
20	50	20	0.7877	0.6123	0.0516	0.6598	0.3631		
0.6376									
20	50	30	0.8417	0.7161	0.0309	0.7485	0.6086		

0.2967									
20	50	40	0.7549	0.5879	0.0924	0.3654	0.1477		
0.4230									
20	50	50	0.7371	0.5440	0.0692	0.6029	0.3910		
0.2333									
20	50	60	0.5223	0.2737	0.2283	0.1035	0.0076		
0.8047									
20	50	70	0.9943	0.9944	0.0034	0.6080	0.3514		
0.1869									
20	50	80	0.8637	0.7341	0.0325	0.5580	0.3074		
0.1970									
20	50	90	0.8061	0.6409	0.0456	0.4827	0.2355		
0.2683									
20	50	100	0.8692	0.7486	0.0219	0.6349	0.3845		
0.1679									
20	60	10	0.7562	0.5149	0.3840	-0.5315	-0.0549		
13.7302									
20	60	20	0.4252	0.1789	0.3308	-0.2434	0.0746		
1.5697									
20	60	30	0.3849	0.1553	0.3834	0.1055	-0.0415		
1.0768									
20	60	40	0.6513	0.4315	0.1271	0.3000	0.1413		
0.7524									
20	60	50	0.7205	0.5074	0.0919	0.4555	0.2246		
0.3258									
20	60	60	0.7178	0.5024	0.0960	0.4928	0.2529		
0.2673									
20	60	70	0.7872	0.6184	0.0454	0.5722	0.3232		
0.1848									
20	60	80	0.9942	0.9932	0.0022	0.6194	0.3857		
0.1452									
20	60	90	0.8208	0.6617	0.0464	0.5984	0.3686		
0.1724									
20	60	100	0.9218	0.8442	0.0091	0.6466	0.4248		
0.1294									
20	70	10	0.1925	0.0148	0.7017	-0.6297	0.5815		
6.0792									
20	70	20	0.7334	0.5418	0.0726	0.2127	0.1575		
1.8799									
20	70	30	0.5737	0.3280	0.1819	0.4152	0.0849		
1.1079									
20	70	40	0.7578	0.5807	0.0629	-0.0969	0.0216		
1.2181									
20	70	50	0.4494	0.2110	0.3114	0.0754	0.0049		
0.8549									
20	70	60	0.8251	0.6763	0.0325	0.7290	0.4760		
0.3810									
20	70	70	0.9093	0.8265	0.0082	0.7870	0.5853		

0.1613									
20	70	80	0.5398	0.2954	0.2135	0.1381	0.0414		
0.7927									
20	70	90	0.8796	0.7655	0.0211	0.6062	0.3587		
0.1627									
20	70	100	0.8190	0.6758	0.0353	0.5743	0.3096		
0.2223									
20	80	10	0.5141	0.2677	0.2373	-0.4320	0.5009		
11.9252									
20	80	20	0.4194	0.1369	0.4891	-0.6177	0.4299		
2.8511									
20	80	30	0.6348	0.4250	0.1818	-0.5173	0.3536		
3.0417									
20	80	40	0.8076	0.6592	0.0418	-0.0126	-0.0246		
1.0865									
20	80	50	0.7285	0.5344	0.0751	0.5691	0.2825		
0.3566									
20	80	60	0.8361	0.6933	0.0302	0.4480	0.1874		
0.3224									
20	80	70	0.8761	0.7627	0.0177	0.7241	0.5661		
0.2509									
20	80	80	0.8000	0.6436	0.0413	0.6437	0.4357		
0.1727									
20	80	90	0.4688	0.2209	0.2823	0.1000	-0.0284		
0.9574									
20	80	100	0.8019	0.6455	0.0398	0.6164	0.3898		
0.1569									
20	90	10	0.4113	0.1397	0.4333	-0.3954	0.4691		
11.7289									
20	90	20	0.5851	0.3418	0.1721	0.5112	0.4141		
2.5739									
20	90	30	0.6841	0.4736	0.1029	0.3746	0.2540		
1.6835									
20	90	40	0.8100	0.6605	0.0380	-0.2851	0.0916		
1.6620									
20	90	50	0.7465	0.5652	0.0706	-0.1196	0.0038		
1.2645									
20	90	60	0.8282	0.6774	0.0368	0.6848	0.5253		
0.4176									
20	90	70	0.8049	0.6501	0.0385	0.6781	0.4241		
0.2311									
20	90	80	0.8317	0.6884	0.0294	0.2756	0.0554		
0.5672									
20	90	90	0.8400	0.7010	0.0277	0.5842	0.3552		
0.1922									
20	90	100	0.8902	0.7942	0.0124	0.5836	0.3239		
0.2012									
20	100	10	0.2978	0.0542	0.6120	0.2509	0.4504		

15.5761									
20   100   20	0.6119	0.3762	0.1509	-0.2168	-0.1263				
4.4854									
20   100   30	0.7802	0.5966	0.0629	-0.1363	-0.0321				
1.5475									
20   100   40	0.6469	0.4312	0.1406	-0.0953	-0.0193				
1.2802									
20   100   50	0.6517	0.4241	0.1213	0.1923	0.0392				
0.6528									
20   100   60	0.6835	0.4635	0.1015	0.1988	0.0456				
0.6456									
20   100   70	0.7593	0.5668	0.0675	0.4902	0.2025				
0.4025									
20   100   80	0.8901	0.7856	0.0166	0.4996	0.2459				
0.2517									
20   100   90	0.7666	0.5806	0.0594	0.6101	0.3964				
0.2101									
20   100   100	0.8551	0.7374	0.0248	0.5540	0.3297				
0.2511									
30   10   10	0.6873	0.4631	0.1065	0.5246	0.2585				
0.2540									
30   10   20	0.7882	0.6310	0.0543	0.4006	0.1547				
0.3626									
30   10   30	0.9854	0.9691	0.0006	0.8098	0.6432				
0.0521									
30   10   40	0.9160	0.8367	0.0076	0.6913	0.4713				
0.0997									
30   10   50	0.9736	0.9503	0.0013	0.7781	0.5988				
0.0537									
30   10   60	0.9078	0.8225	0.0087	0.6037	0.3743				
0.1668									
30   10   70	0.9869	0.9725	0.0004	0.7439	0.5562				
0.0664									
30   10   80	0.9542	0.9078	0.0029	0.7490	0.5578				
0.0640									
30   10   90	1.0036	1.0074	0.0000	0.9051	0.8104				
0.0167									
30   10   100	1.0039	1.0083	0.0000	0.8677	0.7400				
0.0341									
30   20   10	0.4471	0.1827	0.3352	-0.1280	0.0142				
1.2727									
30   20   20	0.3633	0.1293	0.4061	0.0849	0.0084				
0.8375									
30   20   30	0.7953	0.6303	0.0424	0.6131	0.3606				
0.1731									
30   20   40	0.8992	0.8083	0.0102	0.7825	0.6200				
0.0533									
30   20   50	0.8916	0.7895	0.0148	0.6840	0.4635				

0.1018									
30	20	60	0.9493	0.9034	0.0031	0.7149	0.5095		
0.0815									
30	20	70	0.9897	0.9782	0.0003	0.7711	0.5905		
0.0541									
30	20	80	0.9773	0.9543	0.0006	0.8613	0.7340		
0.0254									
30	20	90	0.9570	0.9151	0.0019	0.8161	0.6472		
0.0693									
30	20	100	0.9495	0.9014	0.0026	0.6517	0.4388		
0.1412									
30	30	10	0.3435	0.0856	0.5357	-0.0528	-0.0347		
1.2490									
30	30	20	0.5766	0.3313	0.1794	0.2067	0.0436		
0.6293									
30	30	30	0.8248	0.6685	0.0447	0.5738	0.3211		
0.1883									
30	30	40	0.7735	0.6118	0.0696	0.4379	0.1913		
0.3160									
30	30	50	0.9208	0.8424	0.0092	0.6668	0.4536		
0.1191									
30	30	60	0.8801	0.7775	0.0152	0.8156	0.6352		
0.1233									
30	30	70	0.9520	0.9084	0.0028	0.7285	0.5427		
0.0881									
30	30	80	0.9138	0.8252	0.0170	0.6366	0.3973		
0.1384									
30	30	90	0.9802	0.9625	0.0007	0.8410	0.6972		
0.0352									
30	30	100	0.9369	0.8767	0.0041	0.6892	0.4624		
0.1126									
30	40	10	0.6069	0.3622	0.1583	0.3915	0.1645		
0.3830									
30	40	20	0.7840	0.6102	0.0487	0.5657	0.3503		
0.2803									
30	40	30	0.8007	0.6363	0.0420	0.5625	0.3419		
0.2560									
30	40	40	0.9707	0.9446	0.0014	0.6823	0.4783		
0.1169									
30	40	50	0.8479	0.7145	0.0251	0.5677	0.3351		
0.2034									
30	40	60	0.9249	0.8424	0.0226	0.6546	0.4355		
0.1242									
30	40	70	0.9292	0.8613	0.0054	0.7440	0.5577		
0.0673									
30	40	80	0.9147	0.8359	0.0073	0.7370	0.5351		
0.0758									
30	40	90	0.9866	0.9739	0.0002	0.7857	0.6139		

0.0471									
30	40	100	0.9229	0.8467	0.0084	0.6735	0.4445		
0.1149									
30	50	10	0.4146	0.1861	0.3629	-0.3636	0.2473		
3.1828									
30	50	20	0.7593	0.5807	0.0596	0.5051	0.2315		
0.3006									
30	50	30	0.8675	0.7531	0.0176	0.1279	0.0246		
0.7673									
30	50	40	0.8586	0.7270	0.0305	0.6775	0.4318		
0.1775									
30	50	50	0.8392	0.7096	0.0288	0.6039	0.3736		
0.1648									
30	50	60	0.9435	0.8933	0.0041	0.6763	0.4561		
0.1050									
30	50	70	0.7759	0.6020	0.0502	0.3982	0.1509		
0.3680									
30	50	80	0.8011	0.6358	0.0431	0.5348	0.2883		
0.2170									
30	50	90	0.9940	0.9926	0.0021	0.7837	0.6000		
0.0671									
30	50	100	0.9359	0.8761	0.0041	0.8120	0.6393		
0.0754									
30	60	10	0.2080	0.0382	0.6299	-0.5933	0.3845		
2.6442									
30	60	20	0.8122	0.6634	0.0366	-0.0962	0.0212		
1.2158									
30	60	30	0.6114	0.3798	0.1546	0.3030	0.1235		
0.5865									
30	60	40	0.7361	0.5418	0.0696	0.5648	0.2709		
0.4205									
30	60	50	0.8370	0.7024	0.0269	0.6590	0.4657		
0.2154									
30	60	60	0.7464	0.5516	0.0674	0.4831	0.2012		
0.3706									
30	60	70	0.8689	0.7516	0.0183	0.6981	0.4791		
0.0979									
30	60	80	0.9504	0.9065	0.0035	0.7593	0.5642		
0.0731									
30	60	90	0.9698	0.9379	0.0016	0.8115	0.6363		
0.0849									
30	60	100	0.8667	0.7548	0.0191	0.5600	0.3103		
0.1947									
30	70	10	0.5474	0.2812	0.2388	0.3927	0.3541		
4.3664									
30	70	20	0.7553	0.5851	0.0813	0.0039	-0.0089		
1.0002									
30	70	30	0.8349	0.6890	0.0337	0.6264	0.4369		

0.3381									
30   70   40   0.6547   0.4138   0.1413   0.2256   0.0841									
0.7100									
30   70   50   0.6605   0.4303   0.1188   0.4460   0.2255									
0.3776									
30   70   60   0.8985   0.8097   0.0108   0.5461   0.3043									
0.2098									
30   70   70   0.9192   0.8486   0.0080   0.7512   0.5556									
0.0695									
30   70   80   0.7905   0.6289   0.0456   0.6092   0.3426									
0.2346									
30   70   90   0.9350   0.8833   0.0123   0.7119   0.5191									
0.0979									
30   70   100   0.9293   0.8527   0.0170   0.6525   0.4252									
0.1208									
30   80   10   -0.1869   0.0353   1.4087   -0.4112   -0.0090									
5.1633									
30   80   20   0.5434   0.2948   0.2085   0.3251   0.2317									
2.0442									
30   80   30   0.7068   0.4877   0.1001   0.1548   -0.0475									
1.2243									
30   80   40   0.8473   0.7199   0.0237   0.4849   0.2541									
0.3010									
30   80   50   0.6809   0.4493   0.1222   0.2693   0.0811									
0.5412									
30   80   60   0.8022   0.6416   0.0395   0.4884   0.2675									
0.3456									
30   80   70   0.9934   0.9902   0.0011   0.7307   0.5754									
0.2447									
30   80   80   0.8522   0.7327   0.0260   0.5957   0.3549									
0.1634									
30   80   90   0.9221   0.8518   0.0063   0.7756   0.5739									
0.1270									
30   80   100   0.8801   0.7704   0.0161   0.7844   0.5924									
0.0990									
30   90   10   0.5179   0.2400   0.3118   -0.6733   0.3346									
4.2088									
30   90   20   0.7241   0.5384   0.0958   -0.3204   0.1093									
1.7478									
30   90   30   0.5693   0.3142   0.1953   0.3115   0.1402									
0.6604									
30   90   40   0.5628   0.3246   0.1973   -0.0567   0.0340									
1.2115									
30   90   50   0.7663   0.5922   0.0570   0.5707   0.3551									
0.2701									
30   90   60   0.6719   0.4616   0.1182   0.3822   0.1435									
0.3823									
30   90   70   0.8463   0.7163   0.0236   0.7135   0.5290									

0.1216									
30   90   80	0.7749	0.6008	0.0507	0.5368	0.2721				
0.2401									
30   90   90	0.8396	0.6956	0.0345	0.5932	0.3371				
0.1873									
30   90   100	0.8821	0.7748	0.0150	0.6738	0.4648				
0.1178									
30   100   10	0.4854	0.2063	0.3510	-0.2253	0.2267				
4.5968									
30   100   20	0.7987	0.6436	0.0437	-0.4124	0.1663				
1.9962									
30   100   30	0.5758	0.3233	0.1867	0.3427	0.0202				
1.3769									
30   100   40	0.9009	0.8164	0.0121	0.4605	0.2457				
0.4040									
30   100   50	0.7453	0.5504	0.0675	0.4135	0.2060				
0.4664									
30   100   60	0.7855	0.6182	0.0462	0.6661	0.4137				
0.2017									
30   100   70	0.9500	0.8976	0.0049	0.6583	0.4147				
0.1513									
30   100   80	0.7901	0.6228	0.0443	0.6456	0.4410				
0.1844									
30   100   90	0.9661	0.9217	0.0148	0.5664	0.3175				
0.1891									
30   100   100	0.8812	0.7764	0.0141	0.7070	0.5168				
0.1144									
40   10   10	0.6730	0.4583	0.1097	0.4049	0.1817				
0.3857									
40   10   20	0.7981	0.6361	0.0408	0.6534	0.4434				
0.1472									
40   10   30	0.9712	0.9486	0.0037	0.8428	0.7152				
0.0272									
40   10   40	1.0015	1.0015	0.0002	0.8507	0.7217				
0.0227									
40   10   50	0.9944	0.9853	0.0012	0.7491	0.5608				
0.0630									
40   10   60	0.9949	0.9895	0.0000	0.9744	0.9460				
0.0019									
40   10   70	1.0070	1.0126	0.0003	0.8781	0.7799				
0.0226									
40   10   80	1.0070	1.0142	0.0001	0.8419	0.7097				
0.0251									
40   10   90	0.9945	0.9884	0.0001	1.0522	1.1082				
0.0029									
40   10   100	1.0007	1.0014	0.0000	0.9876	0.9700				
0.0031									
40   20   10	0.6821	0.4505	0.1228	0.4266	0.1791				



0.3296									
40	20	20	0.7461	0.5561	0.0645	0.2877	0.0769		
0.5109									
40	20	30	0.7834	0.6112	0.0475	0.5044	0.2015		
0.5265									
40	20	40	0.8837	0.7778	0.0145	0.7165	0.5132		
0.0804									
40	20	50	1.0076	1.0160	0.0001	0.8587	0.7227		
0.0416									
40	20	60	0.9867	0.9735	0.0002	0.8021	0.6488		
0.0421									
40	20	70	0.9812	0.9561	0.0047	0.7039	0.4826		
0.1042									
40	20	80	0.9971	0.9928	0.0002	0.8500	0.7124		
0.0328									
40	20	90	0.9980	0.9964	0.0000	0.9115	0.8133		
0.0388									
40	20	100	0.9833	0.9672	0.0003	0.7740	0.5856		
0.0690									
40	30	10	0.7513	0.5534	0.0740	0.6075	0.4138		
0.3544									
40	30	20	0.6678	0.4352	0.1218	0.2796	0.0731		
0.5216									
40	30	30	0.8564	0.7255	0.0270	0.6216	0.3897		
0.1443									
40	30	40	0.8639	0.7448	0.0188	0.5400	0.2917		
0.2116									
40	30	50	0.8786	0.7682	0.0161	0.5831	0.3236		
0.2005									
40	30	60	0.9900	0.9737	0.0042	0.7593	0.5585		
0.0904									
40	30	70	0.9630	0.9245	0.0022	0.7486	0.5604		
0.0632									
40	30	80	0.9092	0.8228	0.0097	0.6065	0.3454		
0.2052									
40	30	90	0.9978	0.9965	0.0001	0.8199	0.6774		
0.0352									
40	30	100	0.9931	0.9866	0.0001	0.8728	0.7698		
0.0228									
40	40	10	0.8265	0.6936	0.0412	0.1049	0.0502		
0.9544									
40	40	20	0.6007	0.3572	0.1608	0.2011	-0.0041		
0.8370									
40	40	30	0.6458	0.4156	0.1257	0.2640	0.0502		
0.5798									
40	40	40	0.8454	0.7198	0.0265	0.5315	0.2886		
0.2234									
40	40	50	0.9317	0.8636	0.0066	0.7737	0.6099		

0.0642									
40	40	60	1.0203	1.0377	0.0015	0.7488	0.5619		
0.0633									
40	40	70	0.9827	0.9656	0.0003	0.7964	0.6470		
0.0576									
40	40	80	1.0032	1.0065	0.0000	0.8183	0.6556		
0.0528									
40	40	90	0.9726	0.9424	0.0020	0.7339	0.5197		
0.1066									
40	40	100	0.9822	0.9666	0.0007	0.7532	0.5716		
0.0628									
40	50	10	0.7186	0.5182	0.0795	0.3844	0.0677		
1.0205									
40	50	20	0.6772	0.4585	0.1042	0.0916	0.0407		
0.9295									
40	50	30	0.8884	0.7859	0.0136	0.4817	0.2116		
0.3103									
40	50	40	0.8522	0.7277	0.0221	0.6665	0.4526		
0.1182									
40	50	50	0.8592	0.7308	0.0253	0.7135	0.4941		
0.1044									
40	50	60	0.9418	0.8823	0.0057	0.7619	0.5670		
0.0749									
40	50	70	0.9587	0.9215	0.0022	0.7255	0.5238		
0.0760									
40	50	80	0.8925	0.7946	0.0119	0.3963	0.1694		
0.3797									
40	50	90	0.9852	0.9696	0.0003	0.8237	0.6706		
0.0372									
40	50	100	0.9425	0.8869	0.0035	0.6989	0.4639		
0.1508									
40	60	10	0.3172	0.1101	0.4752	-0.1220	0.0470		
1.3621									
40	60	20	0.2525	0.0232	0.7230	-0.1599	-0.0121		
1.4872									
40	60	30	0.8514	0.7150	0.0318	0.6176	0.3987		
0.1760									
40	60	40	0.8258	0.6804	0.0306	0.5757	0.3415		
0.1899									
40	60	50	0.8540	0.7250	0.0232	0.5591	0.3058		
0.1990									
40	60	60	0.7674	0.5782	0.0656	0.4218	0.1879		
0.3444									
40	60	70	0.9375	0.8807	0.0042	0.7375	0.5471		
0.0699									
40	60	80	0.8899	0.7885	0.0133	0.6537	0.4101		
0.1495									
40	60	90	0.9483	0.9006	0.0029	0.7432	0.5381		

0.0863									
40	60	100	0.9811	0.9587	0.0018	0.6924	0.4819		
0.0952									
40	70	10	0.2639	0.0244	0.7463	-0.3303	0.2417		
3.5284									
40	70	20	0.3225	0.1085	0.4611	-0.0830	0.0068		
1.1729									
40	70	30	0.6935	0.4659	0.1165	0.3855	0.1137		
0.4992									
40	70	40	0.8777	0.7662	0.0167	0.6937	0.5109		
0.1821									
40	70	50	0.8255	0.6835	0.0309	0.4716	0.2393		
0.3076									
40	70	60	0.8608	0.7345	0.0235	0.6423	0.4310		
0.1619									
40	70	70	0.9070	0.8179	0.0109	0.6732	0.4478		
0.1097									
40	70	80	0.8628	0.7445	0.0188	0.5875	0.3667		
0.2169									
40	70	90	0.8840	0.7843	0.0143	0.5521	0.2951		
0.2101									
40	70	100	0.9725	0.9443	0.0009	0.7662	0.5768		
0.0652									
40	80	10	0.7838	0.6001	0.0673	-0.5103	0.2244		
2.4103									
40	80	20	0.5651	0.3015	0.2207	-0.0466	0.0140		
1.1092									
40	80	30	0.8885	0.7932	0.0139	0.3710	0.1267		
0.4077									
40	80	40	0.5035	0.2381	0.2703	0.0801	0.0235		
0.8754									
40	80	50	0.8720	0.7668	0.0205	0.6109	0.3733		
0.1514									
40	80	60	0.8756	0.7626	0.0171	0.6563	0.4282		
0.1188									
40	80	70	0.9446	0.8937	0.0033	0.8522	0.7056		
0.0643									
40	80	80	0.8254	0.6837	0.0310	0.5924	0.3597		
0.1740									
40	80	90	0.9642	0.9331	0.0025	0.7812	0.6241		
0.0668									
40	80	100	0.9115	0.8303	0.0079	0.6450	0.4308		
0.1477									
40	90	10	0.6742	0.4435	0.1183	0.0217	0.1158		
2.2867									
40	90	20	0.6654	0.4396	0.1129	0.2715	0.0565		
0.5603									
40	90	30	0.4793	0.2342	0.2730	-0.1106	-0.0072		

1.2712									
40   90   40   0.8220   0.6738   0.0320   0.4514   0.1936									
0.3113									
40   90   50   0.9370   0.8822   0.0058   0.5703   0.3120									
0.2022									
40   90   60   0.8496   0.7236   0.0230   0.5293   0.2627									
0.2518									
40   90   70   0.8072   0.6608   0.0458   0.5032   0.2527									
0.2468									
40   90   80   0.9263   0.8626   0.0074   0.6493   0.4347									
0.1401									
40   90   90   0.9514   0.9018   0.0036   0.7503   0.5806									
0.0936									
40   90   100   0.9024   0.8140   0.0095   0.7276   0.5282									
0.0744									
40   100   10   0.7122   0.4936   0.1015   0.0523   -0.1131									
2.2401									
40   100   20   0.7859   0.6082   0.0547   0.1421   0.0017									
0.7701									
40   100   30   0.5751   0.3344   0.1819   -0.0253   0.0394									
1.2018									
40   100   40   0.7365   0.5497   0.0746   0.6049   0.3257									
0.3182									
40   100   50   0.8315   0.6891   0.0289   0.5611   0.3220									
0.1977									
40   100   60   0.8383   0.7063   0.0274   0.5507   0.2851									
0.2348									
40   100   70   0.9573   0.9166   0.0018   0.5986   0.3709									
0.1768									
40   100   80   0.9669   0.9426   0.0070   0.5535   0.2856									
0.2422									
40   100   90   0.9234   0.8497   0.0067   0.7006   0.4963									
0.0927									
40   100   100   0.9172   0.8434   0.0073   0.6781   0.4813									
0.1497									
50   10   10   0.7442   0.5474   0.0695   0.5182   0.2932									
0.2929									
50   10   20   0.9762   0.9547   0.0008   0.8578   0.7313									
0.0222									
50   10   30   0.9201   0.8449   0.0067   0.6961   0.4828									
0.0927									
50   10   40   1.0079   1.0184   0.0007   0.7117   0.5147									
0.0897									
50   10   50   0.9852   0.9711   0.0002   0.8523   0.7200									
0.0259									
50   10   60   1.0074   1.0145   0.0001   0.8945   0.7996									
0.0112									
50   10   70   0.9863   0.9723   0.0002   0.9095   0.8228									

0.0101								
50   10   80   1.0046   1.0096	0.0000   0.9814   0.9595							
0.0017								
50   10   90   0.9978   0.9952	0.0000   0.9726   0.9432							
0.0015								
50   10   100   1.0002   1.0000	0.0000   0.9958   0.9876							
0.0016								
50   20   10   0.5259   0.2652	0.2378   -0.1009   0.0263							
1.2380								
50   20   20   0.7972   0.6340	0.0414   0.5358   0.2994							
0.2305								
50   20   30   1.0036   1.0070	0.0000   0.8063   0.6480							
0.0380								
50   20   40   0.9786   0.9591	0.0006   0.7210   0.5013							
0.1125								
50   20   50   0.9832   0.9703	0.0016   0.8024   0.6322							
0.0527								
50   20   60   0.9880   0.9736	0.0007   0.8102   0.6484							
0.0424								
50   20   70   1.0067   1.0128	0.0001   0.8820   0.7803							
0.0145								
50   20   80   0.9947   0.9900	0.0001   0.9823   0.9710							
0.0040								
50   20   90   0.9977   0.9943	0.0001   0.9227   0.8525							
0.0061								
50   20   100   0.9988   0.9981	0.0000   0.8649   0.7457							
0.0188								
50   30   10   0.1366   0.0457	0.8185   -0.3885   0.1565							
1.9311								
50   30   20   0.6743   0.4591	0.1080   0.3978   0.1815							
0.4165								
50   30   30   0.7922   0.6364	0.0511   0.2512   0.0358							
0.6353								
50   30   40   0.9209   0.8422	0.0096   0.7788   0.5819							
0.1099								
50   30   50   0.9821   0.9656	0.0005   0.8688   0.7502							
0.0194								
50   30   60   0.9981   0.9941	0.0004   0.7919   0.6187							
0.0504								
50   30   70   0.9926   0.9849	0.0001   0.8808   0.7713							
0.0162								
50   30   80   1.0087   1.0185	0.0002   0.9562   0.9267							
0.0170								
50   30   90   1.0066   1.0131	0.0000   0.9350   0.8814							
0.0094								
50   30   100   0.9950   0.9893	0.0001   0.8737   0.7696							
0.0198								
50   40   10   0.5081   0.2597	0.2422   0.3401   0.0559							

0.7927								
50	40	20	0.8325	0.6815	0.0415	0.4890	0.2411	
0.2615								
50	40	30	0.8276	0.6843	0.0298	0.5729	0.3217	
0.1866								
50	40	40	0.9022	0.8198	0.0129	0.6254	0.3997	
0.1476								
50	40	50	0.9297	0.8648	0.0050	0.7100	0.5181	
0.1038								
50	40	60	0.9979	0.9956	0.0000	0.7915	0.6088	
0.0748								
50	40	70	0.9755	0.9481	0.0019	0.7585	0.5845	
0.0667								
50	40	80	0.9753	0.9537	0.0013	0.6679	0.4586	
0.1260								
50	40	90	0.9505	0.9029	0.0025	0.8045	0.6316	
0.0625								
50	40	100	0.9277	0.8575	0.0062	0.7464	0.5575	
0.0643								
50	50	10	0.3828	0.1657	0.4178	0.1427	0.0695	
0.9766								
50	50	20	0.7361	0.5438	0.0700	0.5316	0.2837	
0.2195								
50	50	30	0.9467	0.8961	0.0028	0.6149	0.3728	
0.1511								
50	50	40	0.8799	0.7783	0.0160	0.6786	0.4743	
0.1224								
50	50	50	0.9441	0.8943	0.0041	0.8094	0.6327	
0.0864								
50	50	60	0.9992	0.9983	0.0000	0.9024	0.8313	
0.0381								
50	50	70	0.9693	0.9426	0.0019	0.7678	0.5839	
0.0570								
50	50	80	0.9578	0.9159	0.0020	0.8587	0.7522	
0.0421								
50	50	90	0.9792	0.9568	0.0008	0.8427	0.7133	
0.0258								
50	50	100	0.9976	0.9954	0.0000	0.8560	0.7297	
0.0217								
50	60	10	0.5534	0.2938	0.2150	-0.2280	0.0825	
1.6013								
50	60	20	0.7367	0.5517	0.0773	0.4025	0.1079	
0.6500								
50	60	30	0.8499	0.7237	0.0227	0.5812	0.3434	
0.1785								
50	60	40	0.8315	0.6946	0.0294	0.8107	0.6920	
0.1564								
50	60	50	0.9287	0.8519	0.0163	0.7698	0.6184	

0.1194									
50	60	60	0.9316	0.8681	0.0047	0.8418	0.6901		
0.0595									
50	60	70	0.9097	0.8297	0.0086	0.7348	0.5546		
0.0918									
50	60	80	0.9735	0.9478	0.0007	0.8048	0.6446		
0.0391									
50	60	90	1.0020	1.0045	0.0000	0.7635	0.5871		
0.0577									
50	60	100	0.9910	0.9820	0.0001	0.8220	0.6757		
0.0317									
50	70	10	0.4815	0.2360	0.2706	0.0143	-0.0458		
1.1835									
50	70	20	0.6493	0.4021	0.1613	0.1479	-0.0440		
1.1596									
50	70	30	0.6476	0.4129	0.1284	0.3324	0.1641		
0.7325									
50	70	40	0.8576	0.7409	0.0232	0.3716	0.1210		
0.4243									
50	70	50	0.8361	0.7034	0.0287	0.6153	0.3858		
0.1532									
50	70	60	0.9282	0.8636	0.0056	0.6940	0.4881		
0.0977									
50	70	70	0.8352	0.6982	0.0272	0.5840	0.3206		
0.2150									
50	70	80	0.9691	0.9395	0.0010	0.7956	0.6376		
0.0440									
50	70	90	0.9339	0.8664	0.0077	0.6745	0.4873		
0.2108									
50	70	100	0.9770	0.9582	0.0019	0.8067	0.6602		
0.0464									
50	80	10	0.3663	0.1339	0.4016	-0.2114	-0.0284		
2.0011									
50	80	20	0.7909	0.6168	0.0514	0.7179	0.4836		
0.1809									
50	80	30	0.7482	0.5628	0.0643	0.5421	0.2664		
0.2848									
50	80	40	0.8376	0.6968	0.0286	0.6491	0.4459		
0.1839									
50	80	50	0.8922	0.8001	0.0133	0.6025	0.3532		
0.1676									
50	80	60	0.9737	0.9499	0.0010	0.6573	0.4275		
0.1195									
50	80	70	0.9232	0.8430	0.0146	0.6702	0.4213		
0.1869									
50	80	80	0.9195	0.8470	0.0067	0.7245	0.5100		
0.0982									
50	80	90	0.9895	0.9737	0.0029	0.8017	0.6498		

0.0443									
50   80   100	0.9894	0.9776	0.0003	0.7003	0.4862				
0.0916									
50   90   10	0.3303	0.0755	0.5614	-0.2223	-0.0117				
1.8669									
50   90   20	0.5060	0.2307	0.3080	-0.0756	-0.0340				
1.3145									
50   90   30	0.9537	0.9054	0.0038	0.5438	0.2914				
0.2100									
50   90   40	0.8729	0.7712	0.0246	0.6707	0.4787				
0.1917									
50   90   50	0.8337	0.6969	0.0280	0.5832	0.3349				
0.1765									
50   90   60	0.9320	0.8697	0.0048	0.6671	0.4544				
0.1196									
50   90   70	0.8281	0.6912	0.0325	0.6882	0.4553				
0.1306									
50   90   80	0.9488	0.9010	0.0027	0.7382	0.5371				
0.0747									
50   90   90	0.9761	0.9506	0.0010	0.6664	0.4388				
0.1141									
50   90   100	1.0078	1.0174	0.0003	0.7516	0.5587				
0.0656									
50   100   10	0.5960	0.3611	0.1667	-0.3192	-0.0329				
3.5578									
50   100   20	0.8540	0.7177	0.0348	0.2534	0.0318				
0.6626									
50   100   30	0.7253	0.5410	0.0975	0.6330	0.3449				
0.4461									
50   100   40	0.9609	0.9197	0.0029	0.7654	0.5561				
0.1433									
50   100   50	0.9519	0.9021	0.0039	0.5990	0.3484				
0.1716									
50   100   60	0.9002	0.8156	0.0127	0.6175	0.3584				
0.1986									
50   100   70	0.8779	0.7723	0.0152	0.5673	0.2937				
0.2664									
50   100   80	0.8961	0.8068	0.0123	0.5838	0.3146				
0.2423									
50   100   90	0.9283	0.8560	0.0085	0.7156	0.4882				
0.1378									
50   100   100	0.9272	0.8564	0.0064	0.7385	0.5473				
0.0687									
60   10   10	0.6523	0.4278	0.1214	0.0699	0.0195				
0.8864									
60   10   20	1.0067	1.0116	0.0004	0.9483	0.9106				
0.0157									
60   10   30	1.0042	1.0083	0.0000	0.9358	0.8736				



0.0046								
60   10   40   0.9956   0.9923   0.0001   0.8988   0.8118								
0.0118								
60   10   50   0.9845   0.9701   0.0003   0.8161   0.6699								
0.0352								
60   10   60   1.0008   1.0010   0.0000   0.9983   0.9931								
0.0012								
60   10   70   0.9880   0.9763   0.0001   0.9280   0.8567								
0.0072								
60   10   80   0.9953   0.9904   0.0000   1.0228   1.0479								
0.0008								
60   10   90   0.9951   0.9897   0.0001   1.0111   1.0203								
0.0005								
60   10   100   1.0007   1.0015   0.0000   0.9879   0.9761								
0.0002								
60   20   10   0.6474   0.4030   0.1505   0.2150   0.0060								
0.7781								
60   20   20   0.9281   0.8554   0.0088   0.7895   0.6163								
0.0492								
60   20   30   0.9507   0.9070   0.0034   0.6594   0.4440								
0.1245								
60   20   40   0.9152   0.8337   0.0087   0.6776   0.4665								
0.1094								
60   20   50   0.9910   0.9812   0.0002   0.8594   0.7364								
0.0203								
60   20   60   1.0086   1.0157   0.0003   0.8803   0.7746								
0.0143								
60   20   70   0.9955   0.9914   0.0000   0.9096   0.8294								
0.0086								
60   20   80   1.0023   1.0047   0.0000   0.9189   0.8397								
0.0087								
60   20   90   1.0000   1.0000   0.0000   0.9116   0.8232								
0.0139								
60   20   100   1.0031   1.0050   0.0001   0.9578   0.9224								
0.0042								
60   30   10   0.7521   0.5624   0.0625   0.5940   0.3292								
0.2206								
60   30   20   1.0289   1.0568   0.0011   0.7867   0.6075								
0.0584								
60   30   30   0.9242   0.8479   0.0095   0.5854   0.3190								
0.2277								
60   30   40   1.0131   1.0271   0.0002   0.8625   0.7503								
0.0231								
60   30   50   0.9766   0.9543   0.0006   0.7982   0.6387								
0.0410								
60   30   60   0.9918   0.9826   0.0002   0.8856   0.7857								
0.0133								
60   30   70   1.0009   1.0018   0.0000   0.9213   0.8450								

0.0076									
60   30   80   0.9698   0.9392   0.0011   0.7528   0.5616									
0.0637									
60   30   90   0.9962   0.9916   0.0001   0.8501   0.7150									
0.0282									
60   30   100   1.0092   1.0188   0.0001   0.8990   0.8107									
0.0108									
60   40   10   0.7569   0.5705   0.0597   0.5812   0.3228									
0.1980									
60   40   20   0.6606   0.4254   0.1272   0.2719   0.0861									
0.5449									
60   40   30   0.8584   0.7286   0.0270   0.5484   0.3075									
0.2086									
60   40   40   0.8023   0.6429   0.0391   0.6334   0.4165									
0.1575									
60   40   50   1.0114   1.0220   0.0002   0.8206   0.6760									
0.0328									
60   40   60   0.9815   0.9609   0.0009   0.6238   0.3868									
0.1421									
60   40   70   0.9951   0.9893   0.0001   0.8209   0.6678									
0.0358									
60   40   80   0.9762   0.9507   0.0011   0.8734   0.7566									
0.0199									
60   40   90   1.0084   1.0181   0.0002   0.8300   0.6714									
0.0592									
60   40   100   0.9905   0.9813   0.0001   0.8409   0.7108									
0.0266									
60   50   10   0.7610   0.5689   0.0677   0.7195   0.4684									
0.3215									
60   50   20   0.8461   0.7151   0.0238   0.6348   0.4140									
0.1455									
60   50   30   0.9445   0.8951   0.0039   0.7803   0.5984									
0.0592									
60   50   40   0.9096   0.8285   0.0083   0.8022   0.6148									
0.1219									
60   50   50   1.0117   1.0199   0.0014   0.6545   0.4173									
0.1315									
60   50   60   0.9720   0.9432   0.0010   0.8195   0.6752									
0.0339									
60   50   70   1.0056   1.0102   0.0001   0.8310   0.7050									
0.0491									
60   50   80   1.0097   1.0194   0.0001   0.8284   0.6905									
0.0313									
60   50   90   1.0052   1.0101   0.0000   0.8374   0.7093									
0.0329									
60   50   100   1.0127   1.0265   0.0002   0.8762   0.7576									
0.0256									
60   60   10   0.2084   0.0604   0.6555   -0.2229   0.0219									

1.5728									
60	60	20	0.6639	0.4342	0.1173	0.3159	0.1241		
0.5272									
60	60	30	0.9436	0.8896	0.0032	0.5883	0.3512		
0.1720									
60	60	40	0.9442	0.8924	0.0032	0.7899	0.6372		
0.0616									
60	60	50	0.8542	0.7303	0.0213	0.5552	0.3244		
0.2240									
60	60	60	0.9168	0.8366	0.0084	0.5692	0.3209		
0.1865									
60	60	70	0.9271	0.8602	0.0054	0.7358	0.5580		
0.0970									
60	60	80	0.9526	0.9053	0.0027	0.7080	0.4987		
0.0859									
60	60	90	1.0009	1.0018	0.0000	0.8842	0.7786		
0.0144									
60	60	100	1.0128	1.0265	0.0002	0.8459	0.7038		
0.0374									
60	70	10	0.1786	0.0305	0.6749	-0.0911	0.0576		
1.4340									
60	70	20	0.6628	0.4351	0.1155	0.3614	0.0975		
0.5176									
60	70	30	0.8102	0.6526	0.0375	0.5796	0.3511		
0.1999									
60	70	40	0.8284	0.6935	0.0348	0.5501	0.2954		
0.2076									
60	70	50	0.9258	0.8588	0.0058	0.8214	0.6606		
0.0518									
60	70	60	0.9485	0.8959	0.0041	0.7182	0.5170		
0.0795									
60	70	70	0.9653	0.9283	0.0025	0.7251	0.5350		
0.0842									
60	70	80	0.9537	0.9098	0.0021	0.7598	0.5746		
0.0584									
60	70	90	0.9882	0.9770	0.0002	0.8372	0.7055		
0.0286									
60	70	100	1.0004	1.0002	0.0000	0.8683	0.7458		
0.0242									
60	80	10	0.4868	0.2519	0.2858	0.3903	0.2147		
0.7612									
60	80	20	0.6244	0.3814	0.1483	0.2053	0.0244		
0.6630									
60	80	30	0.7996	0.6371	0.0406	0.5244	0.2532		
0.2738									
60	80	40	0.7013	0.5026	0.1008	0.3445	0.1371		
0.4634									
60	80	50	0.9678	0.9381	0.0013	0.7553	0.5790		

0.0670								
60   80   60	1.0018	1.0057	0.0004	0.6943	0.4842			
0.0939								
60   80   70	0.9552	0.9094	0.0029	0.7249	0.5417			
0.1018								
60   80   80	0.9935	0.9859	0.0002	0.9055	0.8000			
0.0486								
60   80   90	1.0158	1.0337	0.0006	0.8483	0.7170			
0.0237								
60   80   100	0.9996	0.9995	0.0000	0.7768	0.5900			
0.0678								
60   90   10	0.8118	0.6503	0.0430	0.1974	-0.0636			
1.6960								
60   90   20	0.8695	0.7485	0.0227	0.7788	0.5652			
0.2196								
60   90   30	0.7311	0.5315	0.0732	0.5035	0.2763			
0.2981								
60   90   40	0.9418	0.8914	0.0054	0.7023	0.4777			
0.1126								
60   90   50	0.9539	0.9020	0.0084	0.7040	0.4983			
0.0884								
60   90   60	0.9254	0.8557	0.0056	0.7440	0.5495			
0.0672								
60   90   70	0.9129	0.8350	0.0078	0.6264	0.3861			
0.1436								
60   90   80	0.9990	0.9999	0.0003	0.8343	0.6766			
0.0651								
60   90   90	0.9110	0.8331	0.0089	0.7104	0.5112			
0.0881								
60   90   100	0.9901	0.9827	0.0007	0.7364	0.5374			
0.0719								
60   100   10	0.6643	0.4395	0.1130	-0.0343	0.0572			
1.3841								
60   100   20	0.6605	0.4333	0.1161	0.3868	0.0963			
0.6605								
60   100   30	0.8022	0.6385	0.0416	0.6543	0.4721			
0.3130								
60   100   40	0.8638	0.7460	0.0186	0.8148	0.6319			
0.1372								
60   100   50	0.8849	0.7865	0.0144	0.6699	0.4516			
0.1098								
60   100   60	0.8268	0.6890	0.0329	0.4677	0.1956			
0.3369								
60   100   70	0.9825	0.9644	0.0004	0.7910	0.6142			
0.0567								
60   100   80	0.9849	0.9675	0.0008	0.7633	0.5918			
0.0644								
60   100   90	0.8612	0.7464	0.0215	0.6261	0.4030			

0.1520									
60	100	100	0.9664	0.9349	0.0012	0.8186	0.6728		
0.0336									
70	10	10	0.9369	0.8806	0.0047	0.8005	0.6424		
0.0400									
70	10	20	1.0096	1.0226	0.0011	0.7610	0.5827		
0.0584									
70	10	30	0.9978	0.9953	0.0000	0.7932	0.6282		
0.0429									
70	10	40	1.0068	1.0145	0.0001	0.9862	0.9789		
0.0041									
70	10	50	1.0010	1.0023	0.0000	0.9796	0.9674		
0.0065									
70	10	60	0.9853	0.9707	0.0002	0.9253	0.8570		
0.0057									
70	10	70	0.9991	0.9986	0.0000	0.9239	0.8541		
0.0058									
70	10	80	1.0004	1.0005	0.0000	0.9853	0.9734		
0.0008									
70	10	90	0.9950	0.9900	0.0000	1.0373	1.0765		
0.0014									
70	10	100	1.0007	1.0011	0.0000	1.0175	1.0360		
0.0004									
70	20	10	0.6986	0.4981	0.1011	0.5554	0.2883		
0.2382									
70	20	20	0.8527	0.7261	0.0218	0.6887	0.4653		
0.1050									
70	20	30	0.9892	0.9748	0.0015	0.7205	0.5223		
0.0791									
70	20	40	1.0006	1.0026	0.0002	0.8797	0.7855		
0.0278									
70	20	50	1.0087	1.0168	0.0001	0.8052	0.6398		
0.0452									
70	20	60	1.0001	0.9991	0.0001	0.8179	0.6634		
0.0362									
70	20	70	1.0028	1.0044	0.0002	0.7932	0.6342		
0.0453									
70	20	80	0.9932	0.9876	0.0002	0.8744	0.7547		
0.0255									
70	20	90	1.0021	1.0034	0.0001	0.9521	0.9060		
0.0023									
70	20	100	0.9946	0.9893	0.0000	0.9724	0.9401		
0.0038									
70	30	10	0.5809	0.3295	0.1819	0.0212	0.0117		
0.9708									
70	30	20	0.8255	0.6750	0.0346	0.6569	0.4152		
0.1443									
70	30	30	0.9584	0.9125	0.0054	0.6321	0.3872		

0.1507								
70   30   40	0.9483	0.8966	0.0034	0.6741	0.4419			
0.1220								
70   30   50	0.9997	1.0012	0.0003	0.8437	0.7054			
0.0285								
70   30   60	0.9935	0.9871	0.0000	0.8749	0.7589			
0.0199								
70   30   70	1.0071	1.0139	0.0001	0.8415	0.7072			
0.0252								
70   30   80	0.9965	0.9931	0.0000	0.8733	0.7614			
0.0162								
70   30   90	1.0027	1.0045	0.0001	0.9228	0.8443			
0.0112								
70   30   100	0.9985	0.9970	0.0000	0.9604	0.9172			
0.0042								
70   40   10	0.2683	0.0722	0.5354	-0.0834	0.0242			
1.2037								
70   40   20	0.8753	0.7651	0.0157	0.7040	0.5161			
0.1300								
70   40   30	0.9192	0.8419	0.0075	0.7333	0.5260			
0.0849								
70   40   40	0.9907	0.9818	0.0001	0.8754	0.7555			
0.0274								
70   40   50	0.9432	0.8867	0.0041	0.7945	0.6206			
0.0536								
70   40   60	0.9913	0.9813	0.0002	0.8492	0.7304			
0.0313								
70   40   70	0.9951	0.9900	0.0000	0.8256	0.6854			
0.0318								
70   40   80	0.9929	0.9860	0.0001	0.9234	0.8689			
0.0324								
70   40   90	1.0025	1.0043	0.0001	0.8818	0.7773			
0.0140								
70   40   100	0.9918	0.9841	0.0001	0.9187	0.8502			
0.0103								
70   50   10	0.9304	0.8628	0.0057	0.6766	0.4275			
0.1963								
70   50   20	0.8118	0.6546	0.0374	0.7676	0.6250			
0.1824								
70   50   30	0.9774	0.9569	0.0008	0.7729	0.5910			
0.0557								
70   50   40	0.9541	0.9126	0.0027	0.7650	0.5827			
0.0559								
70   50   50	0.9050	0.8200	0.0091	0.7479	0.5631			
0.0649								
70   50   60	0.9576	0.9173	0.0018	0.7557	0.5788			
0.0655								
70   50   70	0.9884	0.9772	0.0001	0.8680	0.7480			

0.0204								
70	50	80	1.0001	1.0004	0.0000	0.8829	0.7779	
0.0140								
70	50	90	0.9910	0.9821	0.0001	0.8335	0.6897	
0.0302								
70	50	100	0.9987	0.9979	0.0000	0.8866	0.7962	
0.0231								
70	60	10	0.6097	0.3692	0.1530	0.1940	0.0392	
0.6498								
70	60	20	0.6073	0.3614	0.1596	0.2107	0.0194	
0.6857								
70	60	30	0.8664	0.7589	0.0247	0.6047	0.3349	
0.2510								
70	60	40	0.9462	0.8950	0.0029	0.8211	0.6893	
0.0549								
70	60	50	0.9105	0.8252	0.0094	0.6250	0.3840	
0.1450								
70	60	60	0.9883	0.9723	0.0020	0.7747	0.5856	
0.0721								
70	60	70	0.9872	0.9743	0.0002	0.7580	0.5757	
0.0587								
70	60	80	1.0075	1.0136	0.0003	0.8515	0.7256	
0.0221								
70	60	90	0.9992	1.0000	0.0002	0.8089	0.6507	
0.0378								
70	60	100	0.9933	0.9877	0.0001	0.8242	0.6852	
0.0343								
70	70	10	0.1975	0.0427	0.6454	-0.1323	0.0671	
1.5285								
70	70	20	0.8258	0.6744	0.0359	0.6308	0.4260	
0.2152								
70	70	30	0.7888	0.6360	0.0635	0.2764	0.1017	
0.5873								
70	70	40	0.9502	0.9015	0.0027	0.7081	0.5092	
0.0913								
70	70	50	0.9371	0.8777	0.0040	0.6819	0.4690	
0.1027								
70	70	60	0.9198	0.8467	0.0065	0.6686	0.4512	
0.1115								
70	70	70	0.9781	0.9550	0.0008	0.7970	0.6332	
0.0416								
70	70	80	0.9693	0.9404	0.0010	0.6764	0.4514	
0.1085								
70	70	90	0.9934	0.9847	0.0005	0.7536	0.5589	
0.0689								
70	70	100	0.9897	0.9784	0.0002	0.8695	0.7683	
0.0323								
70	80	10	0.7967	0.6303	0.0433	0.4786	0.1396	

1.0709									
70   80   20   0.6565   0.4217   0.1266   0.1986   0.0509									
0.6555									
70   80   30   0.7129   0.5059   0.0830   0.2725   0.0501									
0.5878									
70   80   40   0.8060   0.6445   0.0402   0.5565   0.3152									
0.1997									
70   80   50   0.9948   0.9923   0.0007   0.8133   0.6445									
0.0635									
70   80   60   1.0007   1.0018   0.0000   0.8048   0.6548									
0.0432									
70   80   70   1.0045   1.0090   0.0000   0.8289   0.6831									
0.0309									
70   80   80   0.9785   0.9583   0.0005   0.7343   0.5372									
0.0710									
70   80   90   0.9885   0.9784   0.0003   0.7405   0.5458									
0.0680									
70   80   100   0.9811   0.9651   0.0010   0.7846   0.6285									
0.0632									
70   90   10   0.8097   0.6688   0.0535   0.1715   0.0387									
0.6952									
70   90   20   0.7781   0.6021   0.0504   0.5457   0.2745									
0.2606									
70   90   30   0.8788   0.7754   0.0157   0.6301   0.3798									
0.1663									
70   90   40   0.9797   0.9637   0.0019   0.7630   0.5972									
0.0788									
70   90   50   0.8291   0.6868   0.0292   0.6651   0.4128									
0.1993									
70   90   60   1.0073   1.0174   0.0008   0.8315   0.7091									
0.0597									
70   90   70   0.9588   0.9194   0.0017   0.6505   0.4223									
0.1222									
70   90   80   0.9675   0.9376   0.0013   0.7980   0.6245									
0.0558									
70   90   90   0.9890   0.9810   0.0010   0.7377   0.5418									
0.0694									
70   90   100   0.9844   0.9689   0.0002   0.7997   0.6370									
0.0407									
70   100   10   0.5801   0.3312   0.1792   0.0961   -0.0514									
1.1851									
70   100   20   0.8843   0.7875   0.0163   0.4451   0.1898									
0.3148									
70   100   30   0.8494   0.7155   0.0264   0.6559   0.4033									
0.1912									
70   100   40   0.9010   0.8154   0.0112   0.6719   0.4606									
0.1158									
70   100   50   0.9822   0.9592   0.0034   0.7308   0.5107									



0.1271									
70   100   60	0.8943	0.8009	0.0113	0.7631	0.6018				
0.0940									
70   100   70	0.9258	0.8647	0.0111	0.7556	0.5480				
0.1125									
70   100   80	1.0045	1.0105	0.0002	0.8068	0.6518				
0.0374									
70   100   90	0.9453	0.8930	0.0030	0.8265	0.6607				
0.0806									
70   100   100	0.9731	0.9479	0.0008	0.7711	0.5873				
0.0577									
80   10   10	0.7308	0.5415	0.0781	0.2422	0.0663				
0.5801									
80   10   20	0.9497	0.9066	0.0047	0.7835	0.6255				
0.0601									
80   10   30	0.9883	0.9764	0.0002	0.8754	0.7723				
0.0191									
80   10   40	0.9917	0.9840	0.0001	0.9277	0.8594				
0.0054									
80   10   50	0.9991	0.9987	0.0000	0.9881	0.9794				
0.0011									
80   10   60	1.0051	1.0105	0.0000	0.9579	0.9184				
0.0018									
80   10   70	1.0050	1.0099	0.0000	0.9190	0.8491				
0.0086									
80   10   80	1.0008	1.0020	0.0000	0.9886	0.9754				
0.0005									
80   10   90	0.9940	0.9875	0.0001	1.0203	1.0410				
0.0004									
80   10   100	1.0026	1.0052	0.0000	0.9902	0.9823				
0.0004									
80   20   10	0.6670	0.4494	0.1129	0.0781	-0.0116				
0.8811									
80   20   20	0.8717	0.7593	0.0165	0.6061	0.3641				
0.1562									
80   20   30	1.0056	1.0134	0.0005	0.8609	0.7408				
0.0194									
80   20   40	0.9961	0.9937	0.0003	0.7900	0.6096				
0.0649									
80   20   50	1.0016	1.0028	0.0000	0.9203	0.8464				
0.0064									
80   20   60	0.9892	0.9788	0.0001	0.8709	0.7575				
0.0168									
80   20   70	0.9992	0.9986	0.0000	0.9577	0.9110				
0.0056									
80   20   80	1.0077	1.0157	0.0001	0.9532	0.9125				
0.0037									
80   20   90	1.0008	1.0016	0.0000	0.9889	0.9809				

0.0009									
80	20	100	1.0000	1.0003	0.0000	0.9755	0.9513		
0.0006									
80	30	10	0.7549	0.5708	0.0601	0.5896	0.3707		
0.2215									
80	30	20	0.8068	0.6535	0.0379	0.5675	0.3272		
0.1896									
80	30	30	0.9874	0.9773	0.0007	0.8196	0.6576		
0.0525									
80	30	40	1.0041	1.0089	0.0001	0.7795	0.6030		
0.0507									
80	30	50	1.0031	1.0055	0.0001	0.8963	0.8088		
0.0137									
80	30	60	0.9931	0.9865	0.0001	0.9575	0.9095		
0.0072									
80	30	70	0.9984	0.9966	0.0000	1.0042	1.0117		
0.0011									
80	30	80	0.9975	0.9943	0.0001	0.9248	0.8656		
0.0162									
80	30	90	0.9963	0.9924	0.0000	1.0037	1.0133		
0.0035									
80	30	100	1.0016	1.0032	0.0000	0.9568	0.9136		
0.0022									
80	40	10	0.7438	0.5489	0.0676	0.4933	0.2476		
0.2586									
80	40	20	0.8280	0.6868	0.0297	0.5685	0.3188		
0.1882									
80	40	30	1.0008	1.0009	0.0000	0.8802	0.7585		
0.0411									
80	40	40	1.0138	1.0285	0.0002	0.8834	0.7746		
0.0169									
80	40	50	0.9942	0.9875	0.0001	0.8125	0.6656		
0.0382									
80	40	60	1.0045	1.0100	0.0001	0.8569	0.7340		
0.0205									
80	40	70	0.9938	0.9874	0.0000	0.8142	0.6554		
0.0402									
80	40	80	0.9878	0.9752	0.0002	0.9277	0.8571		
0.0065									
80	40	90	0.9993	0.9990	0.0000	0.9607	0.9288		
0.0048									
80	40	100	0.9975	0.9947	0.0000	1.0274	1.0514		
0.0026									
80	50	10	0.8705	0.7641	0.0207	0.2975	0.0816		
0.4982									
80	50	20	0.8596	0.7337	0.0224	0.5705	0.3335		
0.1911									
80	50	30	0.8559	0.7323	0.0208	0.7040	0.4674		

0.1674								
80	50	40	0.9663	0.9342	0.0012	0.8280	0.6695	
0.0556								
80	50	50	0.9868	0.9757	0.0005	0.7939	0.6407	
0.0531								
80	50	60	0.9905	0.9805	0.0001	0.8487	0.7323	
0.0374								
80	50	70	0.9982	0.9989	0.0007	0.8518	0.7326	
0.0269								
80	50	80	0.9956	0.9902	0.0001	0.8689	0.7498	
0.0199								
80	50	90	1.0014	1.0026	0.0000	0.8697	0.7598	
0.0181								
80	50	100	1.0030	1.0061	0.0000	0.8992	0.8020	
0.0143								
80	60	10	0.7470	0.5602	0.0645	0.3922	0.1606	
0.3741								
80	60	20	0.7971	0.6367	0.0413	0.4202	0.1676	
0.3442								
80	60	30	0.8245	0.6853	0.0338	0.5866	0.3334	
0.1824								
80	60	40	0.9849	0.9701	0.0002	0.7725	0.5911	
0.0550								
80	60	50	0.9819	0.9616	0.0010	0.7968	0.6385	
0.0426								
80	60	60	1.0027	1.0022	0.0010	0.7913	0.6265	
0.0435								
80	60	70	0.9937	0.9867	0.0001	0.7983	0.6408	
0.0420								
80	60	80	1.0098	1.0213	0.0003	0.8095	0.6685	
0.0539								
80	60	90	0.9925	0.9846	0.0001	0.8492	0.7184	
0.0235								
80	60	100	0.9944	0.9892	0.0000	0.8439	0.7236	
0.0375								
80	70	10	0.8263	0.6797	0.0312	0.2525	0.1141	
0.8122								
80	70	20	0.6867	0.4725	0.0982	0.3454	0.1068	
0.4443								
80	70	30	0.8397	0.7053	0.0257	0.5029	0.2566	
0.2484								
80	70	40	1.0088	1.0215	0.0015	0.7148	0.5105	
0.0814								
80	70	50	0.9889	0.9756	0.0007	0.7875	0.6184	
0.0455								
80	70	60	0.9686	0.9372	0.0011	0.8215	0.6833	
0.0388								
80	70	70	1.0137	1.0278	0.0002	0.8754	0.7701	

0.0169								
80	70	80	0.9779	0.9556	0.0005	0.7960	0.6266	
0.0465								
80	70	90	1.0131	1.0282	0.0005	0.8187	0.6805	
0.0435								
80	70	100	1.0148	1.0297	0.0002	0.9314	0.8555	
0.0190								
80	80	10	0.7494	0.5732	0.0762	0.6426	0.5120	
1.1090								
80	80	20	0.8898	0.7913	0.0122	0.3339	0.1034	
0.4503								
80	80	30	0.9872	0.9778	0.0012	0.7625	0.5749	
0.0606								
80	80	40	0.8797	0.7733	0.0145	0.6775	0.4732	
0.1240								
80	80	50	0.9331	0.8708	0.0045	0.7727	0.5975	
0.0517								
80	80	60	0.9692	0.9388	0.0010	0.6980	0.4840	
0.0922								
80	80	70	0.9896	0.9796	0.0001	0.7807	0.6155	
0.0517								
80	80	80	1.0096	1.0188	0.0001	0.8621	0.7368	
0.0232								
80	80	90	0.9898	0.9792	0.0001	0.8313	0.6988	
0.0345								
80	80	100	0.9795	0.9577	0.0007	0.8757	0.7583	
0.0229								
80	90	10	0.4641	0.2106	0.2895	0.2251	0.1016	
0.8593								
80	90	20	0.9316	0.8768	0.0127	0.6298	0.3265	
0.6285								
80	90	30	0.8294	0.6961	0.0358	0.5904	0.3594	
0.1794								
80	90	40	0.9382	0.8800	0.0038	0.8157	0.6866	
0.0793								
80	90	50	0.9989	1.0010	0.0010	0.6928	0.4754	
0.0965								
80	90	60	0.9501	0.9000	0.0032	0.7090	0.5006	
0.0851								
80	90	70	0.9840	0.9750	0.0049	0.7558	0.5539	
0.0898								
80	90	80	0.9900	0.9815	0.0003	0.7862	0.6041	
0.0652								
80	90	90	1.0146	1.0288	0.0002	0.7620	0.5876	
0.0613								
80	90	100	1.0029	1.0057	0.0000	0.8779	0.7663	
0.0169								
80	100	10	0.7861	0.6271	0.0542	-0.1414	0.0188	

1.3030									
80   100   20	0.7033	0.4974	0.0888	0.4127	0.1482				
0.3939									
80   100   30	0.8275	0.6807	0.0314	0.5716	0.3115				
0.2068									
80   100   40	0.8053	0.6504	0.0382	0.5749	0.3314				
0.1808									
80   100   50	0.8845	0.7798	0.0140	0.6390	0.3937				
0.1517									
80   100   60	0.9376	0.8812	0.0043	0.6563	0.4194				
0.1309									
80   100   70	0.9684	0.9379	0.0010	0.7251	0.5300				
0.0773									
80   100   80	0.9736	0.9504	0.0013	0.7716	0.5854				
0.0621									
80   100   90	0.9929	0.9854	0.0001	0.8693	0.7448				
0.0287									
80   100   100	0.9988	0.9974	0.0000	0.8689	0.7567				
0.0175									
90   10   10	0.7290	0.5303	0.0736	0.4627	0.1989				
0.3118									
90   10   20	0.9144	0.8403	0.0091	0.5844	0.3402				
0.1729									
90   10   30	0.9989	0.9963	0.0002	0.9422	0.8826				
0.0060									
90   10   40	0.9993	0.9982	0.0000	0.9407	0.8838				
0.0036									
90   10   50	0.9989	0.9980	0.0000	1.0148	1.0295				
0.0002									
90   10   60	1.0008	1.0012	0.0000	1.0054	1.0118				
0.0001									
90   10   70	0.9957	0.9913	0.0000	0.9862	0.9713				
0.0004									
90   10   80	0.9982	0.9963	0.0000	1.0294	1.0600				
0.0009									
90   10   90	1.0009	1.0020	0.0000	1.0154	1.0306				
0.0003									
90   10   100	1.0003	1.0011	0.0000	0.9867	0.9727				
0.0003									
90   20   10	0.9020	0.8097	0.0111	0.6558	0.4244				
0.1217									
90   20   20	0.9381	0.8785	0.0040	0.7137	0.5118				
0.0825									
90   20   30	0.9978	0.9956	0.0000	0.8140	0.6793				
0.0629									
90   20   40	0.9998	1.0004	0.0001	1.0573	1.1140				
0.0049									
90   20   50	1.0090	1.0187	0.0001	0.8895	0.8024				

0.0249								
90	20	60	0.9953	0.9902	0.0000	0.9504	0.9055	
0.0030								
90	20	70	0.9917	0.9834	0.0001	0.9508	0.9019	
0.0029								
90	20	80	0.9974	0.9948	0.0000	1.0229	1.0437	
0.0012								
90	20	90	0.9999	1.0001	0.0000	0.9683	0.9376	
0.0010								
90	20	100	0.9997	0.9997	0.0000	0.9917	0.9805	
0.0009								
90	30	10	0.7647	0.5734	0.0682	0.4692	0.2309	
0.2932								
90	30	20	0.8602	0.7409	0.0196	0.6097	0.3695	
0.1528								
90	30	30	0.9391	0.8871	0.0065	0.7407	0.5305	
0.1002								
90	30	40	0.9915	0.9831	0.0001	0.8257	0.6828	
0.0305								
90	30	50	0.9984	0.9970	0.0000	0.9165	0.8410	
0.0071								
90	30	60	0.9975	0.9951	0.0000	0.9392	0.8717	
0.0145								
90	30	70	0.9989	0.9969	0.0001	0.8936	0.8026	
0.0130								
90	30	80	0.9962	0.9923	0.0000	0.9677	0.9402	
0.0024								
90	30	90	1.0074	1.0144	0.0001	0.9440	0.8942	
0.0041								
90	30	100	1.0057	1.0112	0.0000	0.9599	0.9197	
0.0019								
90	40	10	0.6174	0.3875	0.1505	0.2983	0.0870	
0.4928								
90	40	20	0.9108	0.8295	0.0080	0.7142	0.5043	
0.0850								
90	40	30	0.8751	0.7595	0.0195	0.7562	0.5549	
0.0882								
90	40	40	0.9676	0.9396	0.0022	0.8384	0.6992	
0.0275								
90	40	50	1.0007	1.0010	0.0000	0.9103	0.8224	
0.0120								
90	40	60	0.9978	0.9970	0.0002	0.8439	0.7000	
0.0393								
90	40	70	1.0056	1.0094	0.0004	0.8756	0.7636	
0.0164								
90	40	80	0.9996	0.9996	0.0000	0.9216	0.8600	
0.0173								
90	40	90	1.0012	1.0024	0.0000	0.9510	0.8968	

0.0082								
90	40	100	0.9986	0.9975	0.0000	0.9485	0.9008	
0.0028								
90	50	10	0.6808	0.4684	0.1043	0.2154	0.0375	
0.6235								
90	50	20	0.8821	0.7762	0.0142	0.5773	0.3338	
0.1787								
90	50	30	0.9603	0.9208	0.0018	0.7170	0.5154	
0.0803								
90	50	40	0.9661	0.9358	0.0017	0.7529	0.5733	
0.0651								
90	50	50	0.9746	0.9498	0.0006	0.8119	0.6662	
0.0404								
90	50	60	1.0034	1.0062	0.0001	0.8431	0.7155	
0.0268								
90	50	70	0.9961	0.9915	0.0001	0.8300	0.6924	
0.0301								
90	50	80	1.0035	1.0068	0.0000	0.9554	0.9182	
0.0049								
90	50	90	0.9981	0.9951	0.0001	0.8611	0.7435	
0.0197								
90	50	100	0.9951	0.9904	0.0000	0.9445	0.8849	
0.0084								
90	60	10	0.6251	0.3864	0.1424	0.3254	0.1050	
0.4552								
90	60	20	0.8135	0.6535	0.0416	0.5189	0.2526	
0.2591								
90	60	30	0.8067	0.6446	0.0411	0.5224	0.2635	
0.2369								
90	60	40	0.9416	0.8879	0.0036	0.7229	0.5072	
0.1005								
90	60	50	0.9958	0.9903	0.0002	0.7416	0.5620	
0.0813								
90	60	60	1.0088	1.0176	0.0001	0.7375	0.5380	
0.0723								
90	60	70	1.0106	1.0224	0.0002	0.8703	0.7665	
0.0251								
90	60	80	1.0055	1.0128	0.0003	0.8153	0.6665	
0.0344								
90	60	90	0.9929	0.9856	0.0001	0.7949	0.6275	
0.0439								
90	60	100	0.9990	0.9984	0.0000	0.9157	0.8488	
0.0175								
90	70	10	0.6722	0.4571	0.1102	0.4576	0.2407	
0.3924								
90	70	20	0.8326	0.6898	0.0292	0.5565	0.3248	
0.2198								
90	70	30	0.8413	0.7075	0.0252	0.6781	0.4396	

0.1444								
90   70   40   0.9767   0.9499   0.0022   0.7455   0.5507								
0.0673								
90   70   50   0.9806   0.9596   0.0007   0.8212   0.6622								
0.0468								
90   70   60   1.0069   1.0145   0.0001   0.7915   0.6320								
0.0465								
90   70   70   0.9787   0.9571   0.0005   0.8310   0.6985								
0.0350								
90   70   80   1.0149   1.0293   0.0003   0.8882   0.7752								
0.0315								
90   70   90   1.0052   1.0108   0.0000   0.8751   0.7659								
0.0156								
90   70   100   0.9998   0.9991   0.0000   0.8763   0.7723								
0.0172								
90   80   10   0.8461   0.7088   0.0287   0.6090   0.3977								
0.2243								
90   80   20   0.8455   0.7023   0.0396   0.5244   0.2629								
0.2409								
90   80   30   0.8949   0.7989   0.0114   0.5381   0.2635								
0.2809								
90   80   40   0.9120   0.8311   0.0078   0.8204   0.6926								
0.0704								
90   80   50   0.8891   0.7896   0.0124   0.5284   0.2655								
0.2412								
90   80   60   0.9229   0.8471   0.0081   0.6142   0.3778								
0.1489								
90   80   70   0.9945   0.9894   0.0000   0.8457   0.7026								
0.0397								
90   80   80   0.9855   0.9706   0.0003   0.8875   0.7984								
0.0239								
90   80   90   1.0047   1.0095   0.0000   0.8437   0.7012								
0.0359								
90   80   100   0.9990   0.9974   0.0000   0.9550   0.8984								
0.0206								
90   90   10   0.7087   0.5204   0.1179   0.4387   0.2942								
1.3505								
90   90   20   0.7885   0.6149   0.0494   0.4299   0.1531								
0.4257								
90   90   30   0.8760   0.7651   0.0159   0.7865   0.6416								
0.0984								
90   90   40   0.9519   0.9097   0.0036   0.6562   0.4355								
0.1206								
90   90   50   0.9997   0.9986   0.0001   0.8172   0.6565								
0.0462								
90   90   60   0.9804   0.9591   0.0008   0.7515   0.5528								
0.0762								
90   90   70   1.0178   1.0352   0.0004   0.7940   0.6180								



0.0579									
90   90   80   1.0024   1.0055   0.0001   0.7705   0.5926									
0.0528									
90   90   90   0.9999   0.9998   0.0000   0.9551   0.9238									
0.0151									
90   90   100   1.0028   1.0056   0.0000   0.8692   0.7481									
0.0224									
90   100   10   0.4998   0.2666   0.2783   0.2576   0.1468									
1.1979									
90   100   20   0.8327   0.6891   0.0298   0.4787   0.2097									
0.3094									
90   100   30   0.9215   0.8532   0.0078   0.7941   0.6011									
0.1295									
90   100   40   1.0034   1.0070   0.0000   0.7910   0.6196									
0.0473									
90   100   50   0.9473   0.8948   0.0035   0.7199   0.5144									
0.0800									
90   100   60   0.9524   0.9083   0.0024   0.6820   0.4800									
0.1234									
90   100   70   0.9892   0.9810   0.0007   0.8323   0.6790									
0.0468									
90   100   80   0.9787   0.9577   0.0005   0.8107   0.6427									
0.0568									
90   100   90   1.0126   1.0257   0.0002   0.8684   0.7413									
0.0337									
90   100   100   0.9875   0.9756   0.0002   0.8570   0.7478									
0.0383									
100   10   10   0.8635   0.7457   0.0186   0.7723   0.5690									
0.1275									
100   10   20   1.0077   1.0135   0.0005   0.8144   0.6524									
0.0463									
100   10   30   1.0039   1.0081   0.0000   1.0014   1.0067									
0.0015									
100   10   40   1.0104   1.0209   0.0001   1.0219   1.0457									
0.0007									
100   10   50   1.0036   1.0063   0.0001   0.9611   0.9282									
0.0036									
100   10   60   1.0022   1.0043   0.0000   0.9711   0.9370									
0.0044									
100   10   70   1.0018   1.0030   0.0000   1.0037   1.0051									
0.0005									
100   10   80   0.9962   0.9926   0.0000   1.0092   1.0206									
0.0005									
100   10   90   0.9975   0.9948   0.0000   1.0015   1.0009									
0.0004									
100   10   100   1.0019   1.0041   0.0000   1.0046   1.0081									
0.0001									
100   20   10   0.6667   0.4324   0.1257   0.3178   0.1242									

0.5191								
100	20	20	1.0121	1.0230	0.0003	0.8343	0.6835	
0.0434								
100	20	30	1.0024	1.0037	0.0001	0.9421	0.8939	
0.0073								
100	20	40	0.9922	0.9846	0.0001	0.8234	0.6848	
0.0358								
100	20	50	1.0015	1.0031	0.0000	0.9292	0.8632	
0.0050								
100	20	60	0.9950	0.9898	0.0000	0.9816	0.9599	
0.0017								
100	20	70	0.9952	0.9905	0.0000	0.9404	0.8845	
0.0036								
100	20	80	1.0050	1.0100	0.0000	0.9556	0.9116	
0.0022								
100	20	90	1.0030	1.0057	0.0000	1.0252	1.0529	
0.0010								
100	20	100	0.9986	0.9973	0.0000	0.9980	0.9942	
0.0003								
100	30	10	0.8377	0.7055	0.0277	0.6600	0.4221	
0.1337								
100	30	20	0.9566	0.9170	0.0023	0.7003	0.4774	
0.1069								
100	30	30	1.0381	1.0747	0.0024	0.7466	0.5703	
0.0808								
100	30	40	1.0009	1.0021	0.0000	0.8365	0.7085	
0.0344								
100	30	50	1.0048	1.0091	0.0000	0.8033	0.6406	
0.0410								
100	30	60	0.9990	0.9979	0.0000	0.8553	0.7307	
0.0210								
100	30	70	1.0040	1.0078	0.0000	0.9987	1.0028	
0.0030								
100	30	80	0.9992	0.9979	0.0000	0.9459	0.8942	
0.0030								
100	30	90	0.9998	0.9996	0.0000	0.9502	0.9042	
0.0027								
100	30	100	0.9944	0.9889	0.0000	0.9606	0.9206	
0.0020								
100	40	10	0.7521	0.5497	0.0869	0.3166	0.1361	
0.5955								
100	40	20	0.8547	0.7271	0.0222	0.5891	0.3290	
0.2012								
100	40	30	0.9723	0.9457	0.0008	0.7703	0.6009	
0.0585								
100	40	40	0.9851	0.9694	0.0003	0.7961	0.6468	
0.0584								
100	40	50	1.0006	1.0002	0.0001	0.9159	0.8459	

0.0121								
100	40	60	0.9951	0.9897	0.0000	0.8765	0.7832	
0.0377								
100	40	70	0.9974	0.9950	0.0000	0.9100	0.8212	
0.0127								
100	40	80	1.0040	1.0077	0.0000	1.0177	1.0416	
0.0039								
100	40	90	0.9990	0.9974	0.0000	0.9827	0.9690	
0.0014								
100	40	100	0.9973	0.9949	0.0000	0.9542	0.9104	
0.0021								
100	50	10	0.8499	0.7208	0.0228	0.6998	0.4722	
0.1208								
100	50	20	0.8152	0.6667	0.0346	0.6324	0.4106	
0.1466								
100	50	30	0.9248	0.8514	0.0071	0.6442	0.4191	
0.1283								
100	50	40	0.9241	0.8557	0.0061	0.6456	0.4156	
0.1258								
100	50	50	0.9878	0.9763	0.0002	0.8431	0.7092	
0.0249								
100	50	60	0.9993	0.9981	0.0000	0.8470	0.7221	
0.0255								
100	50	70	1.0060	1.0116	0.0000	0.8814	0.7749	
0.0145								
100	50	80	1.0031	1.0060	0.0000	0.8798	0.7762	
0.0149								
100	50	90	1.0003	1.0009	0.0000	0.8846	0.7838	
0.0135								
100	50	100	0.9987	0.9972	0.0000	0.9737	0.9546	
0.0049								
100	60	10	0.7769	0.5963	0.0551	0.4476	0.1887	
0.3187								
100	60	20	0.9656	0.9309	0.0014	0.7657	0.6041	
0.0867								
100	60	30	1.0028	1.0079	0.0005	0.8254	0.6641	
0.0599								
100	60	40	0.9455	0.8981	0.0047	0.6901	0.4868	
0.1071								
100	60	50	0.9756	0.9462	0.0036	0.7234	0.5145	
0.0843								
100	60	60	0.9512	0.9047	0.0024	0.7687	0.5701	
0.0967								
100	60	70	1.0128	1.0259	0.0002	0.8629	0.7533	
0.0262								
100	60	80	0.9986	0.9964	0.0001	0.9154	0.8485	
0.0183								
100	60	90	0.9975	0.9952	0.0000	0.9322	0.8743	

0.0075								
100	60	100	0.9988	0.9975	0.0000	0.8878	0.7853	
0.0134								
100	70	10	0.6779	0.4656	0.1074	0.3222	0.0871	
0.4873								
100	70	20	0.9782	0.9643	0.0061	0.7731	0.6135	
0.0768								
100	70	30	0.9221	0.8510	0.0061	0.8268	0.6635	
0.0702								
100	70	40	0.9930	0.9857	0.0001	0.7638	0.5737	
0.0651								
100	70	50	0.9982	0.9984	0.0004	0.8314	0.6824	
0.0360								
100	70	60	0.9999	0.9994	0.0000	0.8200	0.6711	
0.0326								
100	70	70	0.9911	0.9815	0.0002	0.8723	0.7783	
0.0465								
100	70	80	1.0002	1.0006	0.0000	0.8734	0.7647	
0.0164								
100	70	90	0.9998	1.0001	0.0000	0.9035	0.8210	
0.0115								
100	70	100	0.9995	0.9992	0.0000	0.8801	0.7785	
0.0160								
100	80	10	0.7686	0.5892	0.0538	0.6315	0.3671	
0.2360								
100	80	20	0.8903	0.7895	0.0130	0.6341	0.4133	
0.1463								
100	80	30	0.8995	0.8098	0.0101	0.7048	0.4881	
0.0946								
100	80	40	0.9321	0.8671	0.0049	0.7685	0.5870	
0.0548								
100	80	50	0.9868	0.9773	0.0015	0.8010	0.6297	
0.0539								
100	80	60	0.9924	0.9846	0.0001	0.8791	0.7603	
0.0303								
100	80	70	0.9987	0.9979	0.0000	0.8752	0.7650	
0.0157								
100	80	80	1.0017	1.0028	0.0000	0.8414	0.7027	
0.0279								
100	80	90	1.0014	1.0029	0.0000	0.9118	0.8184	
0.0247								
100	80	100	0.9961	0.9915	0.0001	0.9178	0.8378	
0.0088								
100	90	10	0.6279	0.3866	0.1443	0.1150	0.0292	
0.8089								
100	90	20	0.6737	0.4399	0.1260	0.3709	0.1728	
0.5199								
100	90	30	0.9609	0.9285	0.0041	0.5652	0.3152	

0.1909									
100	90	40	1.0034	1.0041		0.0008	0.8217	0.6490	
0.1003									
100	90	50	0.9482	0.8986		0.0027	0.7320	0.5447	
0.0797									
100	90	60	0.9978	0.9948		0.0001	0.8696	0.7664	
0.0273									
100	90	70	0.9954	0.9898		0.0001	0.7277	0.5287	
0.0742									
100	90	80	1.0022	1.0045		0.0000	0.8520	0.7245	
0.0221									
100	90	90	0.9947	0.9897		0.0000	0.8069	0.6454	
0.0405									
100	90	100	1.0026	1.0048		0.0000	0.8528	0.7318	
0.0237									
100	100	10	0.6726	0.4538		0.1073	-0.0511	0.0382	
1.2313									
100	100	20	0.8665	0.7465		0.0197	0.6513	0.4324	
0.1284									
100	100	30	0.7660	0.5918		0.0573	0.3451	0.1223	
0.4298									
100	100	40	0.9605	0.9268		0.0033	0.6719	0.4478	
0.1090									
100	100	50	0.9924	0.9850		0.0001	0.7886	0.6332	
0.0575									
100	100	60	0.9785	0.9567		0.0005	0.7590	0.5808	
0.0603									
100	100	70	0.9972	0.9947		0.0000	0.7972	0.6368	
0.0413									
100	100	80	0.9984	0.9957		0.0001	0.7753	0.5999	
0.0506									
100	100	90	1.0001	1.0004		0.0000	0.8688	0.7626	
0.0234									
100	100	100	1.0008	1.0010		0.0000	0.8889	0.8009	
0.0239									

## 4 Plotando

## 4.1 Criando o data frame

```
[47]: import pandas as pd

data = []

for (quantidade_geracoes, quant_pais, quant_filhos, (best_individuo,
    ↪ avg_individuo)) in results:
    data.append({
```

```

        'Quantidade Gerações': quantidade_geracoes,
        'Quant Pais': quant_pais,
        'Quant Filhos': quant_filhos,
        # Assuming this is accessible and meaningful (e.g., a list or tuple of
        ↪ parameters)
        'Best Genotipo': best_individuo.genotipo,
        'Best Fitness': best_individuo.get_fenotipo(),
        # Similarly, assuming this is a list or tuple
        'Average Genotipo': avg_individuo.genotipo,
        'Average Fitness': avg_individuo.get_fenotipo()
    })

df = pd.DataFrame(data)

df[['Best x', 'Best y']] = pd.DataFrame(
    df['Best Genotipo'].tolist(), index=df.index)

df[['Avg x', 'Avg y']] = pd.DataFrame(
    df['Average Genotipo'].tolist(), index=df.index)

df.drop(['Best Genotipo', 'Average Genotipo'], axis=1, inplace=True)

# Display the first few rows to verify
print(df.head())

```

	Quantidade Gerações	Quant Pais	Quant Filhos	Best Fitness \
0	10	10	10	1.379116
1	10	10	20	0.103474
2	10	10	30	0.576182
3	10	10	40	0.098518
4	10	10	50	0.028048

	Average Fitness	Best x	Best y	Avg x	Avg y
0	4.823054	-0.171733	0.037339	-0.224784	0.232817
1	0.237944	0.678331	0.460300	0.539164	0.306690
2	0.973616	0.308037	0.126091	0.015444	-0.006293
3	0.197438	0.686364	0.472324	0.611570	0.352440
4	0.073292	0.842374	0.715254	0.729478	0.533188

## 4.2 Plotando o gráfico

```

[48]: import numpy as np
import matplotlib.pyplot as plt
from scipy.optimize import minimize

def fn_objetivo(xy):
    x, y = xy

```

```

    return (1-x)**2 + 100*(y-x**2)**2

constraints = [
    {'type': 'ineq', 'fun': lambda xy: -((xy[0]-1)**3 - xy[1] + 1)}, #  $(x-1)^3 - y + 1 \leq 0$ 
    {'type': 'ineq', 'fun': lambda xy: -(xy[0] + xy[1] - 2)} #  $x + y - 2 \leq 0$ 
]

bounds = [(-1.5, 1.5), (-0.5, 2.5)]

initial_guess = [0, 0]

resultado = minimize(fn_objetivo, initial_guess, method='SLSQP', bounds=bounds,
    constraints=constraints)

solution = resultado.x
valor_minimo = resultado.fun

print(f"Solution: x = {solution[0]:.4f}, y = {solution[1]:.4f}")
print(f"Minimum value of the objective function: {valor_minimo:.4f}")

x = np.linspace(-1.5, 1.5, 400)
y = np.linspace(-0.5, 2.5, 400)
X, Y = np.meshgrid(x, y)
Z = (1-X)**2 + 100*(Y-X**2)**2

plt.figure(figsize=(10, 6))
contours = plt.contour(X, Y, Z, levels=np.logspace(-1, 3, 50), cmap='viridis')
plt.clabel(contours, inline=True, fontsize=8)
plt.scatter(solution[0], solution[1], color='red', zorder=5, label=f"Minimum at_
    x={solution[0]:.4f}, y={solution[1]:.4f}")
plt.title('Contour Plot of the Objective Function and Its Minimum')
plt.xlabel('x')
plt.ylabel('y')
plt.legend()
plt.show()

```

Solution: x = 0.0011, y = 0.0033  
 Minimum value of the objective function: 0.9989

