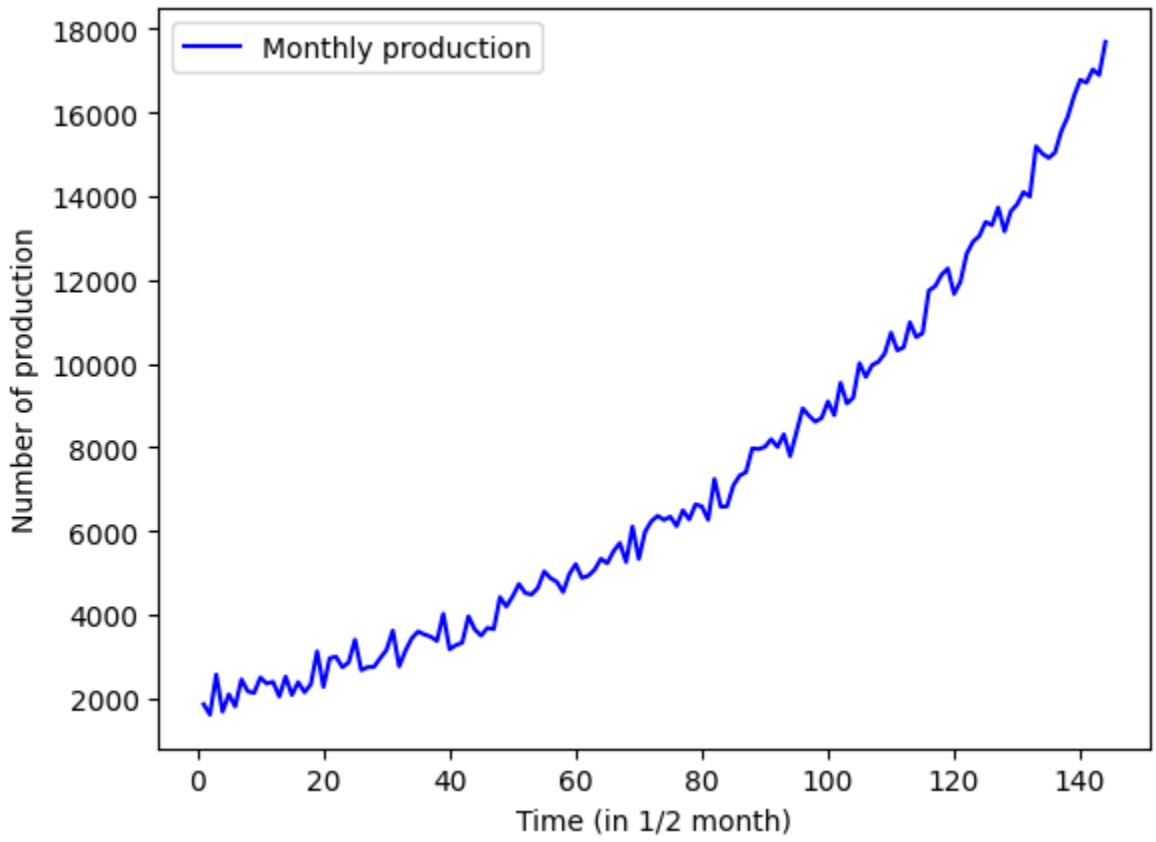
Problem 1:

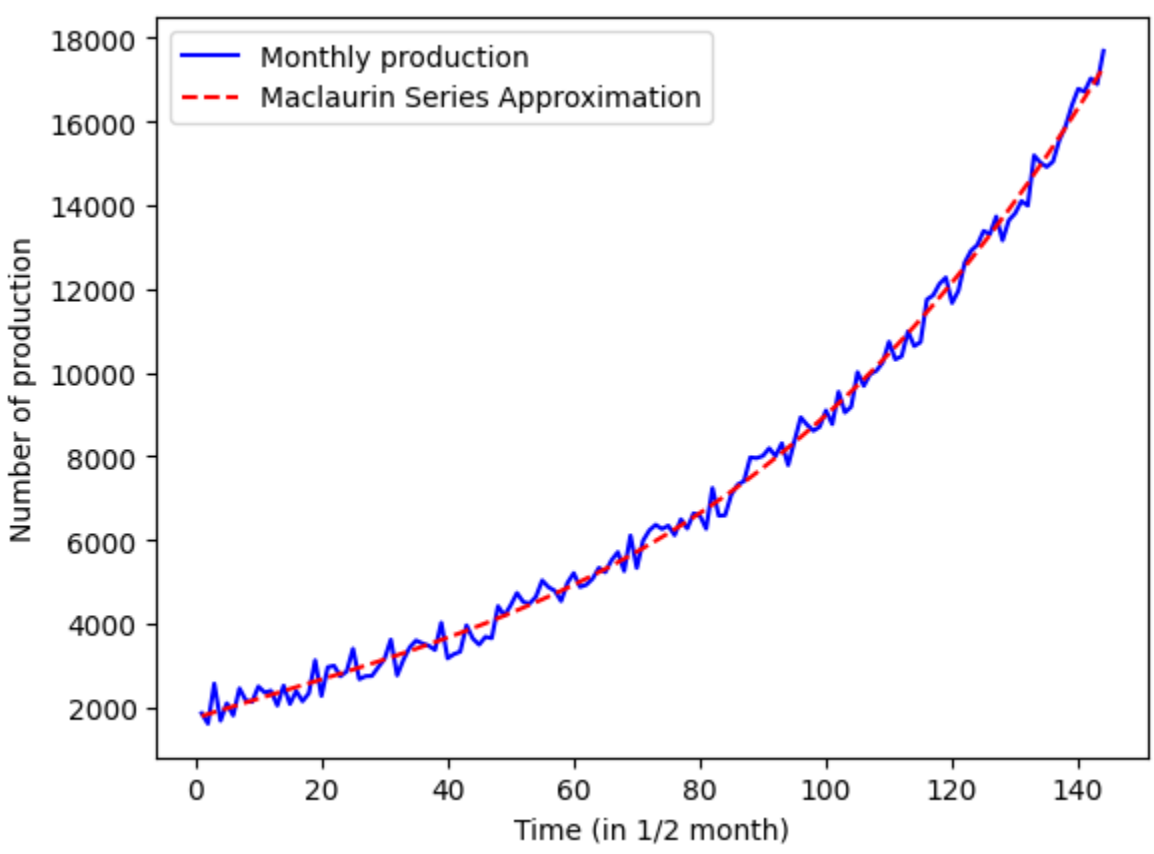
- Soal : Find the trend on the bag's production from the data. You must provide a mathematical model that can explain the production's trend accurately. Since your supervisor wants an accurate model, you must avoid any linear approach to build the trend model.



Dari grafik, dapat dilihat bahwa jumlah monthly production mengalami sebuah peningkatan dari waktu ke waktu. Jadi, monthly production mengalami trend naik.

Problem 2:

- Soal : Since you'll need to process the data using a computer program, you'll need to convert the mathematical model from problem #1 to its numerical form (approximation). This is done so that the mathematical model can be calculated by the program easily. Since accuracy is still important, make sure that your conversion is as accurate as possible. Provide an explanation to your supervisor about the accuracy of your conversion. *The class topic for this question is Introduction to Taylor Series*.



Alasan kami menggunakan model regresi polinomial derajat 3: karena regresi polinomial derajat 3 lebih efektif untuk menangkap kompleksitas dan variasi dalam data. Model ini juga memberikan keseimbangan antara akurasi dan reabilitas dalam prediksi, yang menjadi hal penting untuk warehouse capacity planning dan operasional lainnya.
Fungsi polinomial yang kami dapatkan:
$1748.50672302 + 47.22355255x - 0.13435703x^2 + 0.00386327x^3$

Setelah mendapatkan fungsi polinomialnya, kami mengubahnya menjadi Taylor Series (Maclaurin Series). Taylor series sangat berguna dan sering digunakan untuk melakukan aproksimasi data.

Problem 3:

- Soal : The warehouse was designed to be able to store a maximum of 25,000 (twenty five thousands) bags each month. Your supervisor asked you to provide a prediction when do EGIER need to build a new warehouse based on the trend that you have acquired in problem #2. To build a new warehouse, it is predicted that they need at least 13 months. So provide the time when EGIER needs to start building their new warehouse. (Hint: *this can be approached as a root of equation problem*)

  Dari problem 2, kita mendapatkan persamaan $y = 1748.50672302 + 47.22355255x - 0.13435703x^2 + 0.00386327x^3$ di mana y adalah jumlah produksi dan x adalah jumlah periode waktu (½ bulan). Di problem 3, kita diminta untuk mencari x saat y = 25000. Untuk menyelesaikan persamaan ini, kita menggunakan metode Newton-Raphson. Sebelum itu, kami mengubah fungsi $1748.50672302 + 47.22355255x - 0.13435703x^2 + 0.00386327x^3 = 25000$ menjadi $1748.50672302 + 47.22355255x - 0.13435703x^2 + 0.00386327x^3 - 25000 = 0$. Setelah itu kami menggunakan Newton-Raphson dan didapatkanlah $x = 170.37417474214286$, yang dapat dibulatkan menjadi 170. Karena satu periode waktu adalah ½ bulan, maka 170 periode waktu = 85 bulan. Karena yang ditanyakan adalah kapan pembangunan warehouse baru harus dimulai dan diketahui bahwa waktu yang diperlukan untuk membangun sebuah warehouse adalah 13 bulan, maka 85 - 13 = 72. Warehouse baru dapat mulai dibangun di bulan ke-72 atau pada bulan Desember 2023.

Problem 4:

- Soal : Your supervisor wants to double check your result. Provide the code that you have used to answer problem #1 to #3. Provide your code as a Google Colab URL or a Python script file (.py extension) in your repository. Please make sure that the file is publicly accessible.

  https://colab.research.google.com/drive/1R9qOqSHAXN__RN-3aDo4hpm3SNdO7oej?usp=sharing

```
import matplotlib.pyplot as plt
import numpy as np

# Problem 1
x = [1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,
y = [1863,1614,2570,1685,2101,1811,2457,2171,2134,2502,2358,2399,2048,2523,2086,2391,2150,2340,3129,2277,2964,2997,2747,2862,3405,2677,2749,2755,2963

x = np.array(x)
y = np.array(y)

plt.plot(x, y, 'b-')
plt.xlabel('Time (in 1/2 month)')
plt.ylabel('Number of production')
plt.legend(['Monthly production'])
print('Problem 1')
plt.show()

# Problem 2
from numpy.polynomial.polynomial import Polynomial
import math

coefficients = np.polyfit(x, y, 3) # 3 = degree

p = Polynomial(coefficients[::-1])
# p = fungsi

print('Problem 2')

print('Fungsi polynomial: ', p)
# Dapet p = # 1748.50672302 + 47.22355255·x - 0.13435703·x² + 0.00386327·x³
# Turunan ke 1 = 47.22355255 - 0.13435703 * 2·x + 0.00386327 * 3·x²
# Turunan ke 2 = -0.13435703 * 2 + 0.00386327 * 3 * 2·x
# Turunan ke 3 = 0.00386327 * 3 * 2
# x = 0, pakai maclaurin

maclaurin = p(0) + (47.22355255 * x) + ((-0.13435703 * 2 / math.factorial(2)) * (x ** 2)) + ((0.00386327 * 6 / math.factorial(3)) * (x ** 3))
```

```
plt.plot(x, y, 'b-')
plt.plot(x, maclaurin, 'r--')
plt.xlabel('Time (in 1/2 month)')
plt.ylabel('Number of production')
plt.legend(['Monthly production', 'Maclaurin Series Approximation'])
plt.show()

# Problem 3
# Cari root(x) saat p(x) = 25000, maka p(x) - 25000 = 0
print('Problem 3')

def f(x):
  return p(x) - 25000
def g(x): # turunan f(x)
  return 47.22355255 - 0.13435703 * 2 * x + 0.00386327 * 3 * x ** 2

def newton_raphson(x0, tolerance): # fungsi untuk cari root
  x1 = x0 - f(x0) / g(x0)

  if np.abs(f(x1)) < tolerance:
    print("Root = ", x1)
    return
  newton_raphson(x1, tolerance)

newton_raphson(200, 0.001)

# Tes jumlah tas saat month ke 170
maclaurintest = p(0) + (47.22355255 * 170) + ((-0.13435703 * 2 / math.factorial(2)) * (170 ** 2)) + ((0.00386327 * 6 / math.factorial(3)) * (170 ** 3
print('Jumlah tas saat m ke 170 = ', maclaurintest)

# Pas month ke 171, sudah lebih dari 25000
# Karena butuh 13 bulan buat bangun warehouse baru, jadi warehouse harus dimulai dibangun di m ke...
# 170 - 13 * 2 = 144
# Warehouse harus mulai dibangun di m ke 157 (month ke 144 / 2 = 72)
print('Karena butuh 13 bulan buat bangun warehouse baru, jadi warehouse harus dimulai dibangun di m ke 170 - 13 * 2 = 144')
print('m ke 144 = 72 month')
print('Warehouse harus mulai dibangun di month ke 72 (Desember 2023)')
```

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Problem 1
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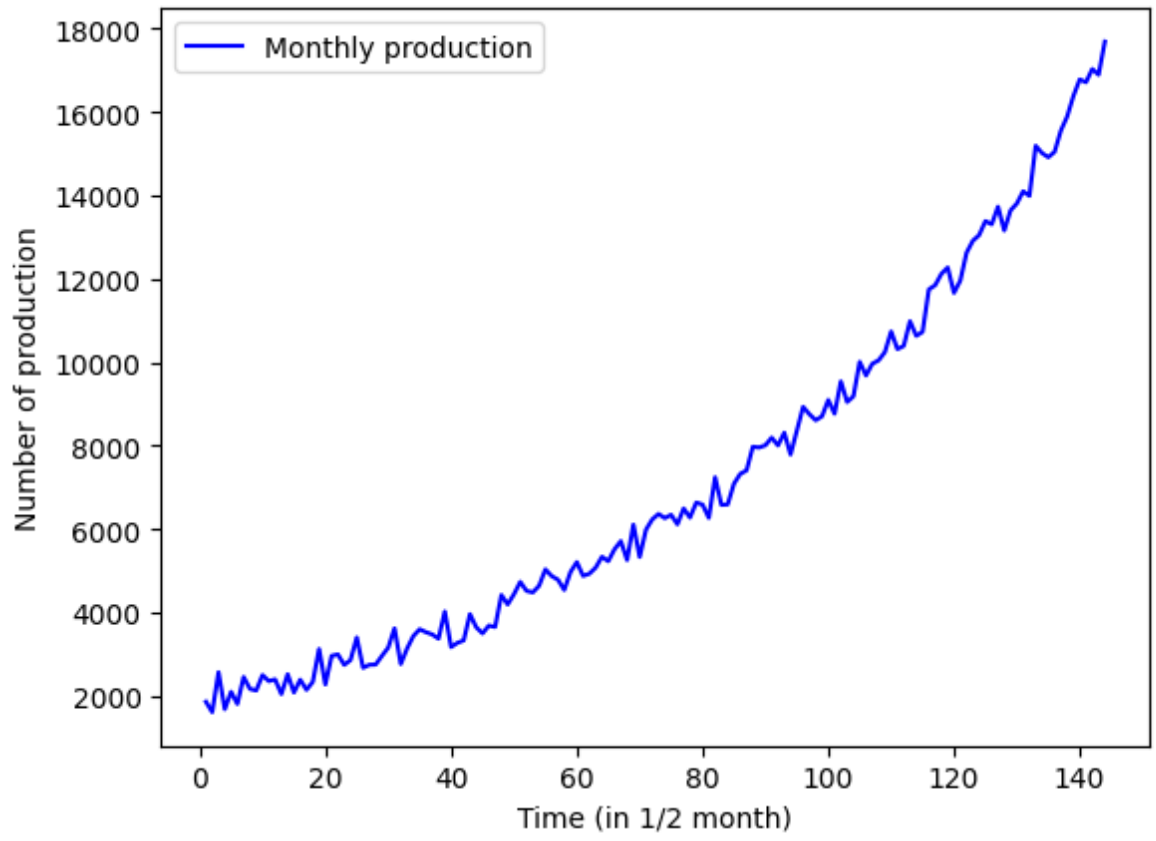
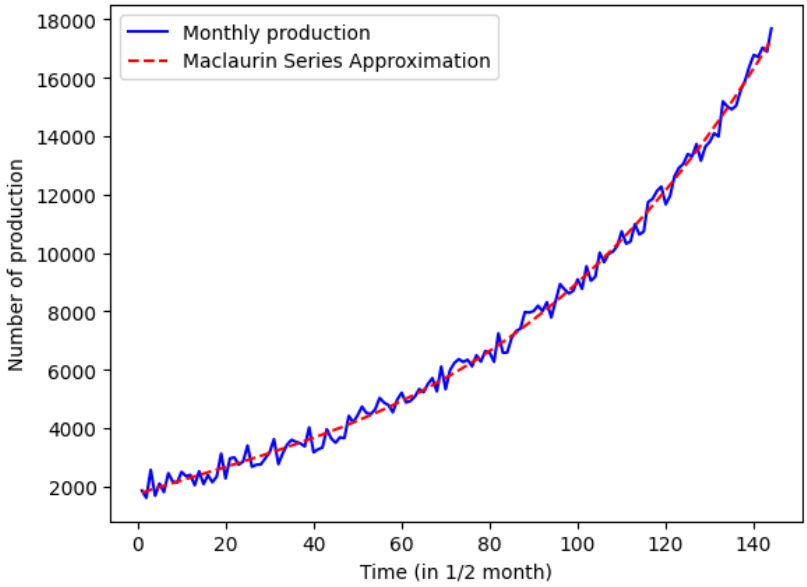


Problem 2
Fungsi polynomial: 1748.50672302 + 47.22355255·x - 0.13435703·x² + 0.00386327·x³



Problem 3
Root = 170.37417474214286
Jumlah tas saat m ke 170 = 24873.837999524258
Karena butuh 13 bulan buat bangun warehouse baru, jadi warehouse harus dimulai dibangun di m ke 170 - 13 * 2 = 144
m ke 144 = month ke 72
Warehouse harus mulai dibangun di month ke 72 (Desember 2023)