# Assigment 1
# MAT3110 - Introduction to numerical analysis

Oliver Ekeberg

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# Contents

# 1 Exercise 1

Use the QR factorization of A and apply back substitution to R1 to find x. You will need to write your own routine for back substitution but you can use the matlab function [Q,R] = qr(A); to find Q and R.

**Ans:**

## 1.1 Back-substitution implementation

I used the built in function for Q and R calculations from numpy. I implemented the following function for back substitution:

```
def back_subst(A: np.ndarray, b: np.ndarray):
    n = b.shape[0]
    if A.shape[0] != A.shape[1]:
        raise ValueError("Input must be square, douche...")
    x = np.zeros(n)
    x[n-1] = b[n-1] / A[n-1, n-1]

    for i in range(n-2, -1, -1):
        x[i] = (b[i] - A[i, i+1:] @ x[i+1:]) / A[i,i]
    return x
```

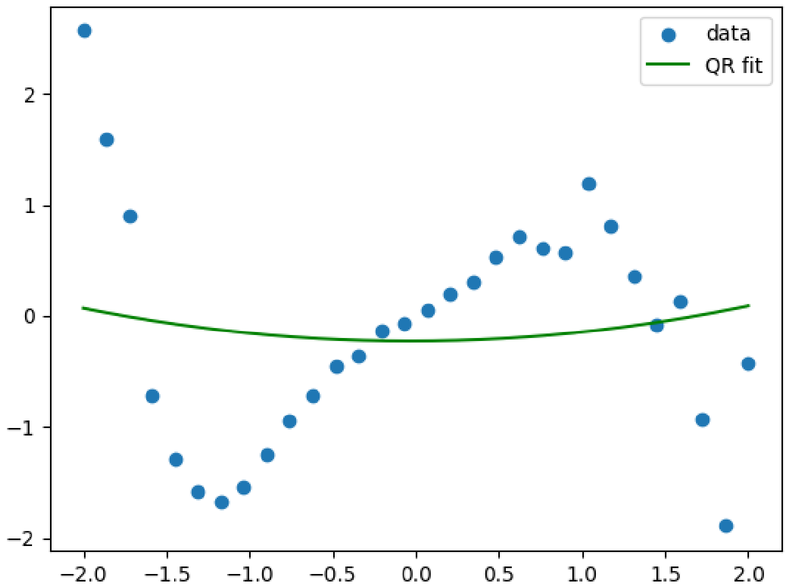
- The code takes input square a upper triangle matrix, and an arbitrary vector b that takes the same shape as the rows and columns of A
- Then I loop backwards from the lower diagonal and up. I have equations of the following form

$$\sum_{j=n}^{n-j} \sum_{i=j+1}^{j=n} a_{ji} x_j = b_j$$

  And we can solve this by taking the dot product of th

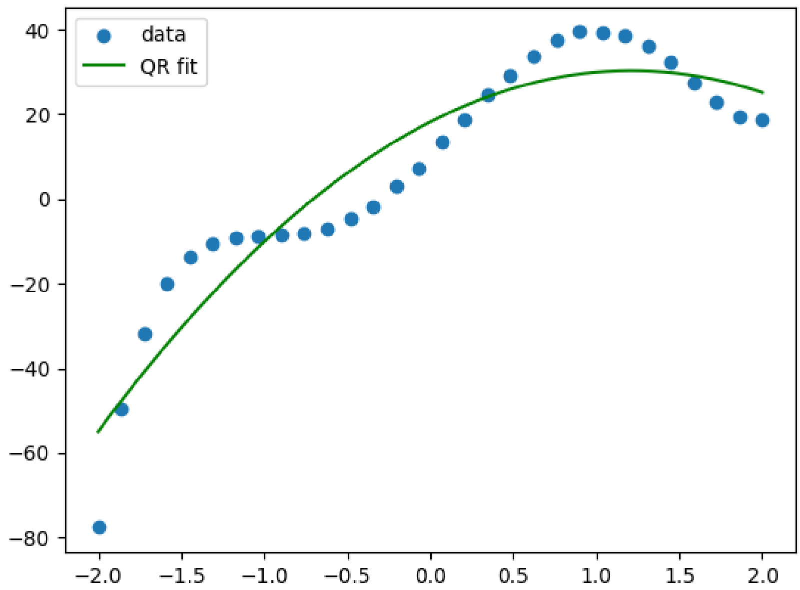
## 1.2 QR plot for dataset 1 m=3

This produced the following plot for data set 1:



### 1.3 QR plot for dataset 2 m=3

And the following plot for dataset 2:



## 2 Exercise 2

The $mxm$ matrix $B = A^T A$ is symmetric and positive definite. Solve the normal equations using the Cholesky factorization $RR^T$ of $B$. To do this you also need to implement forward substitution and the Cholesky algorithm explained in Lecture 3.

**Ans:**

### 2.1 Cholesky implementation

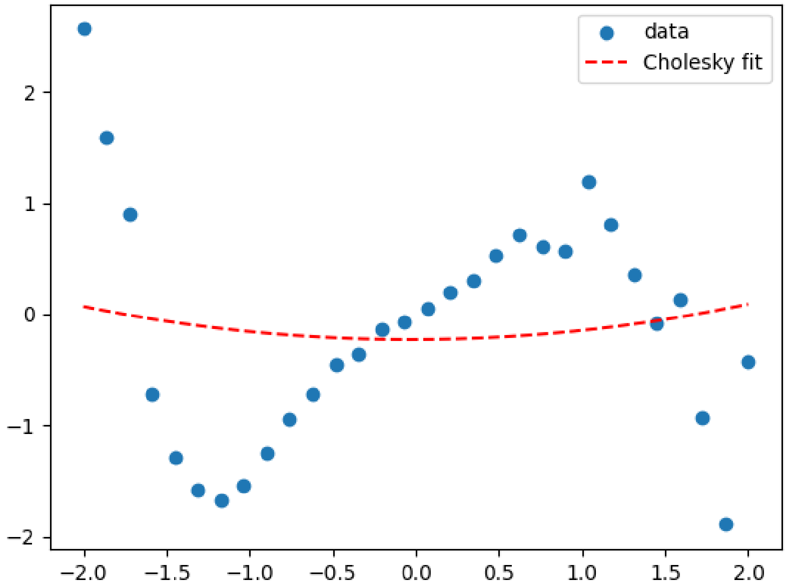
Here is my Cholesky implementation.

```
def cholesky(A):
    A = A.copy().astype(float)
    n = A.shape[0]
    L = np.zeros((n,n))
    D = np.zeros((n,n))
    for i in range(n):
        lk = A[:,i] / A[i,i]
        L[:,i] = lk
        D[i,i] = A[i,i]
        A = A - D[i,i] * np.outer(lk, lk)
    return L, D
```

Here is the figure for the Cholesky interpolation for dataset 1

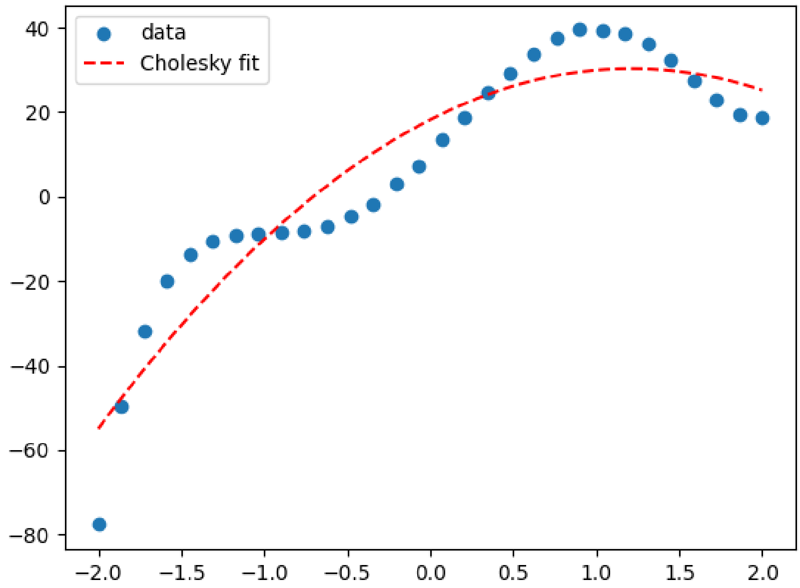
### 2.2 Cholesky plot for dataset 1 m=3

plott 1 for cholesky




### 2.3 Cholesky plot for dataset 2 m=3

her er det andre plottet


data
Cholesky fit
40
20
0
−20
−40
−60
−80
−2.0
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0

# 3 Exercise 3

Here I will discuss the differences