ProgrammingSolution_Sheet1

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## Programming Exercise 1
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## Importing
import numpy as np
import scipy.linalg as linalg
```

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## Creating vectors/matrices
a = np.array([[1],[1],[0]])
b = np.array([[-1],[2],[5]])
M = np.array([[2,-1,0],[-1,2,-1],[0,-1,2]])

## Printing to check
print('a =\n', a)
print('b =\n', b)
print('M =\n', M)
```

```
a =
 [[1]
 [1]
 [0]]
b =
 [[-1]
 [ 2]
 [ 5]]
M =
 [[ 2 -1  0]
 [-1  2 -1]
 [ 0 -1  2]]
```

[5]:
```
## Defining all functions used in this programming exercise

## Function that computes inner product
def inner_product_calc(a, b):
    return np.inner(a,b)

## Function that computes matrix vector product
```

```
def matrix_vector_product_calc(M, b):
    return np.dot(M, b)
#     return M@b ## this works too

## Function that computes vector norm
def norm_calc(a):
    return np.linalg.norm(a)

## Function that computes solution of linear system using LU factorization
def LU_solver(M, b):
    LU = linalg.lu_factor(M)
    return (linalg.lu_solve(LU, b))

## Function that computes solution of linear system using Cholesky factorization
def Cholesky_solver(M, b):
    c, low = linalg.cho_factor(M)
    return (linalg.cho_solve((c, low), b))
```

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## a) Compute and print the inner product between a and b
inner_product = inner_product_calc(a, b)
print("Inner Product =\n", inner_product)
```

```
Inner Product =
 [[-1  2  5]
 [-1  2  5]
 [ 0  0  0]]
```

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## b) Compute and print the matrix-vector product between M and b
matrix_vector_product = matrix_vector_product_calc(M, b)
print("Matrix Vector Product = \n", matrix_vector_product)
```

```
Matrix Vector Product =
 [[-4]
 [ 0]
 [ 8]]
```

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## c) Compute and print the l2 norm of b
l2_norm = norm_calc(b)
print("Norm of vector =", l2_norm)
```

```
Norm of vector = 5.477225575051661
```

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## d) Compute and print the solution x of the linear system of equations Mx=b␣
 ↪using LU factorization
solution_x_using_LU = LU_solver(M, b)
print("Using LU factorization, \nx = \n", solution_x_using_LU)
```

```
Using LU factorization,
x =
 [[1.5]
 [4. ]
 [4.5]]
```

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## e) Compute and print the solution x of the linear system of equations Mx=b␣
 ↪using the Cholesky factorization
solution_x_using_Cholesky = Cholesky_solver(M, b)
print("Using Cholesky factorization, \nx = \n", solution_x_using_Cholesky)
```

```
Using Cholesky factorization,
x =
 [[1.5]
 [4. ]
 [4.5]]
```

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