Computational Methods in Physics (PHY 365)

FA23

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Lab 8

MATLAB's diff function

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- Y = diff(X) calculates differences between adjacent elements of X along the first array dimension whose size does not equal 1.

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- MATLAB's diff function calculates differences and approximate derivatives.
- Y = diff(X) calculates differences between adjacent elements of X along the first array dimension whose size does not equal 1.
- If X is a vector of length m, then Y = diff(X) returns a vector of length m – 1.
  - The elements of Y are the differences between adjacent elements of X.
- If X is a 0-by-0 empty matrix, then Y = diff(X) returns a 0-by-0 empty matrix.

MATLAB's diff function

- Y = diff(X , n) calculates the nth difference by applying the diff(X) operator recursively n times.
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- Y = diff(X , n) calculates the nth difference by applying the diff(X) operator recursively n times.
  - → diff(X , 2) is the same as diff(diff (X)).
- Y = diff(X , n , dim) is the nth difference calculated along the dimension specified by dim.
  - ◇ The dim input is a positive integer scalar.

MATLAB's diff function

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- A = randi(20,1,8);

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- A1 = diff(A);
- A2 = diff(A1);

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- Problem: Create a vector, then compute the differences between the elements.
- A = randi(20,1,8);
- A1 = diff(A);
- A2 = diff(A1);
- A3 = diff(A,2);

MATLAB's diff function

- Problem: Create a matrix, then compute the first difference.

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- A = randi(20,3,5);

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- Problem: Create a matrix, then compute the first difference.
- A = randi(20,3,5);
- A1 = diff(A);
- A2 = diff(A,1,2);

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- Problem: Use the diff function to approximate the first and second derivatives of $\sin(x)$.

MATLAB's diff function

- Problem: Use the diff function to approximate the first and second derivatives of sin (x).

- The step size and domain

```
step_size = 10 ^ -3;

x_vec = - pi : step_size : pi;
```

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- The function

```
f_x = sin(x_vec);
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- The function

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f_x = sin(x_vec);
```

- Calculating the first and second derivatives

```
diff_1 = diff(f_x) / step_size;
diff_2 = diff(f_x , 2) / step_size;
```

MATLAB's diff function

- x_vec for the first and second derivatives

```
diff_x_vec_1 = x_vec( : , 1 : length(diff_1));
diff_x_vec_2 = x_vec( : , 1 : length(diff_2));
```

MATLAB's diff function

- x_vec for the first and second derivatives

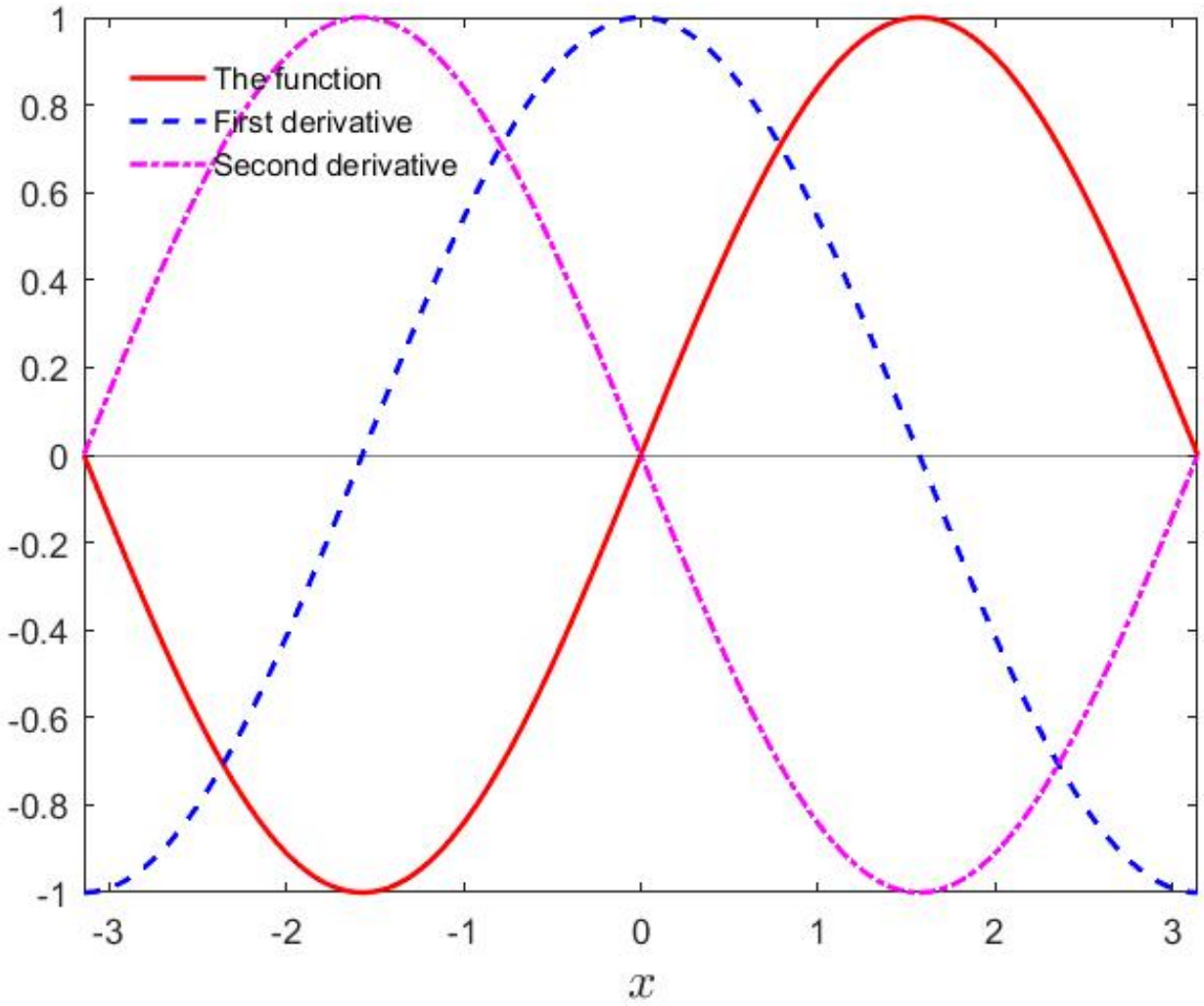
  diff_x_vec_1 = x_vec(: , 1 : length(diff_1));

  diff_x_vec_2 = x_vec(: , 1 : length(diff_2));

- Plotting

  plot(x_vec , f_x ,'r' , diff_x_vec_1 , diff_1 , 'b--' ,
  diff_x_vec_2 , diff_2 , 'm-.')

MATLAB's diff function



MATLAB's gradient function

- FX = gradient(F) returns the one-dimensional numerical gradient of vector F.
  - Here FX corresponds to ∂F/∂x, the differences in "x" (horizontal) direction.
  - The spacing between points is assumed to be 1.

MATLAB's gradient function

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- [FX , FY] = gradient(F) returns the x and y components of the two-dimensional numerical gradient of matrix F.

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  - Here FX corresponds to $\partial F/\partial x$, the differences in "x" (horizontal) direction.
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- [FX , FY] = gradient(F) returns the x and y components of the two-dimensional numerical gradient of matrix F.
- [_____] = gradient(F , h) uses h as a uniform spacing between points in each direction.

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MATLAB's gradient function

- Problem: Use the gradient function to approximate the first and second derivatives of sin (x).

- The step size and domain

```
step_size = 10 ^ -3;
x_vec = - pi : step_size : pi;
```

- The function

```
f_x = sin(x_vec);
```

- Calculating the first and second derivatives

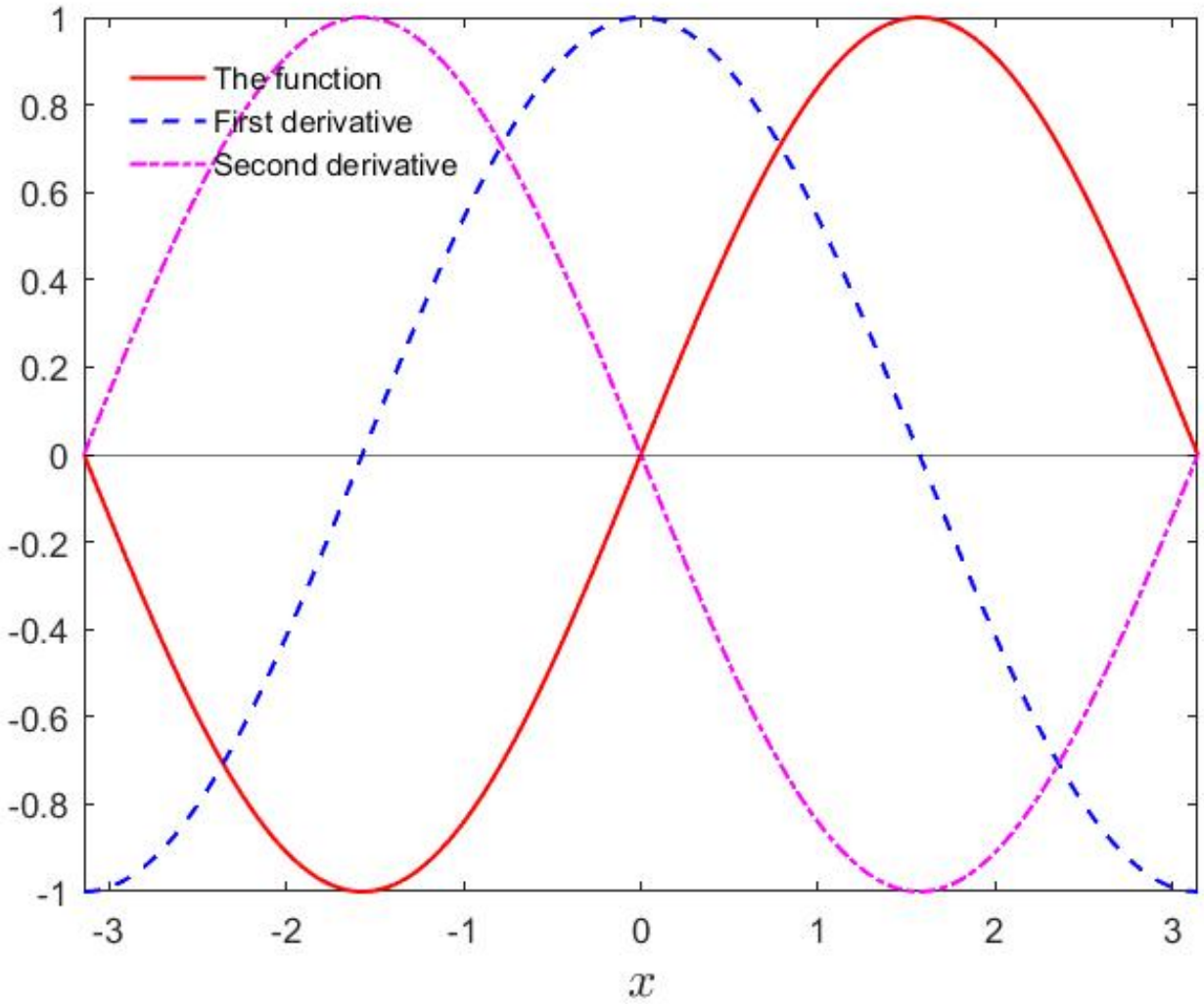
```
grad_1 = gradient(f_x, step_size);
grad_2 = gradient(grad_1 , step_size);
```

MATLAB's gradient function

- Plotting

  plot(x_vec , f_x ,'r' , x_vec , grad_1 , 'b--' , x_vec , grad_2 , 'm-.')

MATLAB's gradient function



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- The diff function can also be used to differentiate symbolic expressions/functions.

MATLAB's diff function

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- Y = diff(f) differentiates the function "f" with respect to the symbolic scalar variable determined by symvar(f , 1).
- Y = diff(f , var) differentiates the function with respect to the differentiation parameter "var".
- The parameter var can be
  - a symbolic scalar variable, such as x,
  - a symbolic function, such as f(x), or
  - a derivative function, such as diff(f(t) , t).

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- The parameter var can be
  - a symbolic scalar variable, such as x,
  - a symbolic function, such as f(x), or
  - a derivative function, such as diff(f(t) , t).
- Y = diff(f , var , n) computes the nth derivative of f with respect to var.

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- f = 3 * x^4 + 50 * x^2 – 10;

- a1 = diff(f);

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- a1 = diff(f);

- a2 = diff(f , x);

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- syms x;
- f = 3 * x^4 + 50 * x^2 – 10;
- a1 = diff(f);
- a2 = diff(f , x);
- a3 = diff(f , x , 2);

MATLAB's diff function

- Problem: Define a function using MATLAB's symbolic toolbox, and find out its derivatives.

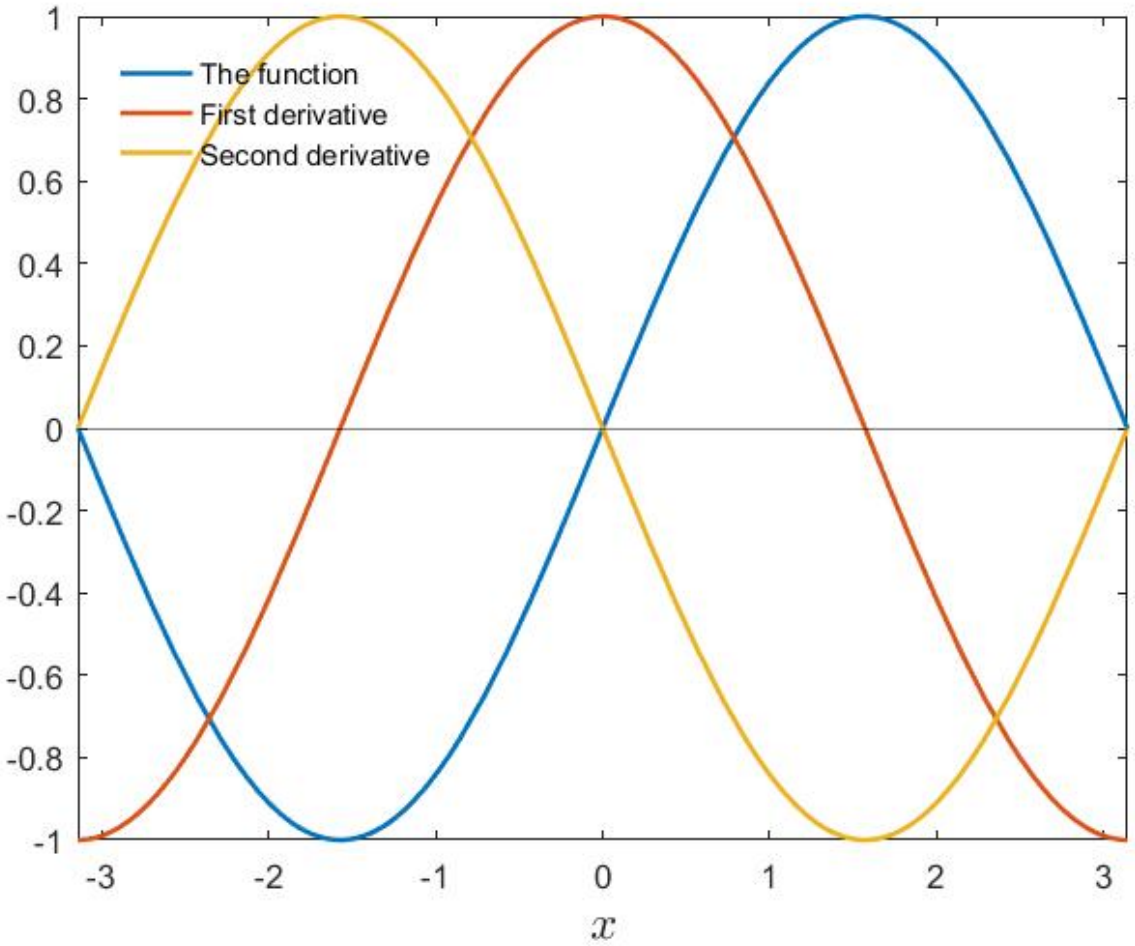
- syms x;
- f = 3 * x^4 + 50 * x^2 – 10;
- a1 = diff(f);
- a2 = diff(f , x);
- a3 = diff(f , x , 2);
- a4 = diff (a2);

MATLAB's diff function

- Problem: Determine the (symbolic) first and second derivatives of $\sin(x)$ using diff function.

MATLAB's diff function

- Problem: Determine the (symbolic) first and second derivatives of sin (x) using diff function.



References

- https://www.mathworks.com/help/matlab/ref/diff.html
- https://www.mathworks.com/help/matlab/ref/gradient.html
- https://www.mathworks.com/help/symbolic/diff.html
- https://www.mathworks.com/help/symbolic/sym.gradient.html