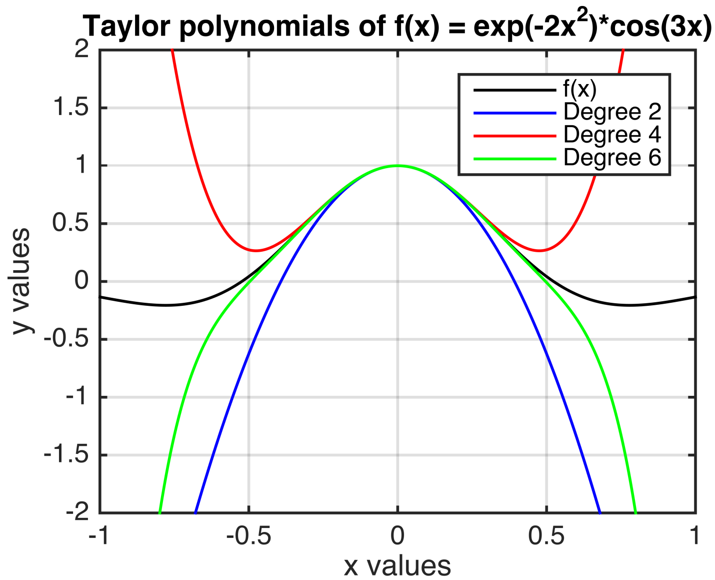
UBC MECH 221: MATLAB Computer Lab 1

Numbers, Arrays, Vectorization, Plotting and Functions




```
>> exp_cos_taylor(2,3)
```

Instructions

Write a function called `exp_cos_taylor` which takes two inputs k and ω and performs the following tasks:

- ☐ In a single figure, plot the function

$$f(x) = e^{-kx^2} \cos(\omega x)$$

  as well as its Taylor polynomials of degree 2, 4 and 6 (centred at $x = 0$) for x in the the interval $[-c, c]$ where

$$c = \min(4\pi/|\omega|, \sqrt{2/|k|})$$

- ☐ You must create arrays, use array operations and the command `plot`. Do **not** use `ezplot` or `fplot`. Do **not** use symbolic computation such as the command `taylor`.

- ☐ Set the limits of the x axis display to $[-c, c]$ and set the y axis limits to $[-2, 2]$.

- ☐ Include a descriptive title which shows the values of k and ω (this requires using the `num2str` function and brackets `[ ]` to concatenate strings (ie. text)):

```
['Plot for k = ', num2str(k) , 'and w = ', num2str(w)]
```

(Note that this is not a good title since it doesn't indicate what is being plotted.)

- ☐ Include axis labels and a legend.
- ☐ Add style to the plot as you see fit such as grid lines, line style, background colour, etc.
- ☐ Write comments at the beginning of your function to describe its purpose and inputs and **include your name and student number**.
- ☐ Test your function with many different inputs.

When you have completed each item above and are satisfied with your function, submit your M-file (called `exp_cos_taylor.m`) to Connect.

Hints

The Taylor series centered at $x = 0$ of a function $f(x)$ (also called the Maclaurin series of $f(x)$) is defined as

$$f(x) = \sum_{n=0}^{\infty} \frac{f^{(n)}(0)}{n!} x^n \ .$$

For example, it is easy to compute

$$e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!} = 1 + x + \frac{x^2}{2} + \frac{x^3}{6} + \frac{x^4}{24} + \cdots$$

and

$$\cos(x) = \sum_{n=0}^{\infty} \frac{(-1)^n x^{2n}}{(2n)!} = 1 - \frac{x^2}{2} + \frac{x^4}{24} + \frac{x^6}{720} + \cdots$$

We can put these two equations together to get

$$\begin{aligned}
&e^{-kx^2} \cos(\omega x) \\
&= \left(1 - kx^2 + \frac{k^2x^4}{2} - \frac{k^3x^6}{6} + \frac{k^4x^8}{24} + \cdots\right)\left(1 - \frac{\omega^2x^2}{2} + \frac{\omega^4x^4}{24} + \frac{\omega^6x^6}{720} + \cdots\right) \\
&= 1 - \left(\frac{w^2}{2} + k\right)x^2 + \left(\frac{k^2}{2} + \frac{kw^2}{2} + \frac{w^4}{24}\right)x^4 - \left(\frac{k^3}{6} + \frac{k^2w^2}{4} + \frac{kw^4}{24} + \frac{w^6}{720}\right)x^6 + \cdots
\end{aligned}$$