Homework assignment – HW3

1.

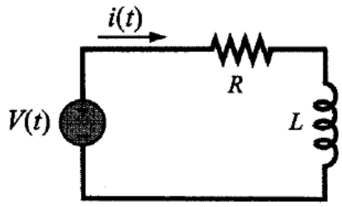
The Gateway Arch in St. Louis is shaped according to the equation:

$$y = 693.8 - 68.8\cosh\left(\frac{x}{99.7}\right) \text{ ft.}$$

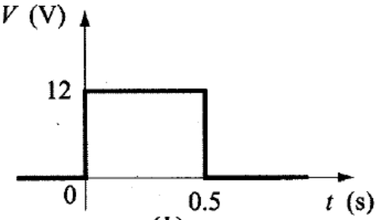
where $-300 \le x \le 300$ **. Make a plot of the arch using a black dashed line. Title your plot.**

2.

A resistor, $R = 4\ \Omega$, and an inductor, $L = 1.3$ H, are connected in a circuit to a voltage source as shown in Figure (*a*) (*RL* circuit). When the voltage source



(*a*)



(*b*)

applies a rectangular voltage pulse with an amplitude of $V = 12$ V and a duration of 0.5 s, shown in Figure (*b*), The current $i(t)$ in the circuit as a function of time is given by:

$$i(t) = \frac{V}{R}(1 - e^{(-Rt)/L}) \quad \text{for } 0 \le t \le 0.5 \text{ s}$$

$$i(t) = e^{-(Rt)/L}\frac{V}{R}(e^{(0.5R)/L} - 1) \quad \text{for } 0.5 \le t \text{ s}$$

Make a plot of the current as a function of time for $0 \le t \le 2$ s.

Use a dashed red line for the first curve and dotted black line for the second curve Title your plot, specify labels, and add corresponding legends

3.

The radial probability density $P_r(r)$ for an excited hydrogen atom at the first excited state (quantum numbers $n = 2$ and $l = 0$) is given by:

$$P_r(r) = \frac{1}{8a_0}\left(\frac{r}{a_0}\right)^2\left(2 - \frac{r}{a_0}\right)e^{(-r/a_0)}$$

where $a_0 = 52.92 \times 10^{-11}$ m is the Bohr radius.

Make a plot of P_r as a function of r/a_0 for $0 \le r/a_0 \le 15$.

Title your plot and specify labels

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4.

a)

Plot the function $f(x) = 7x^3 + 5x^2 + 7x$ ($-30 \le x \le 30$) and its first and second derivatives in three subplots. Title your plots and use a different line color for each plot.

b)

The position x as a function of time of a particle that moves along a straight line is given by:

$$x(t) = 0.4t^3 - 2t^2 - 5t + 13 \text{ m}$$

The velocity $v(t)$ of the particle is determined by the derivative of $x(t)$ with respect to t, and the acceleration $a(t)$ is determined by the derivative of $v(t)$ with respect to t.

Derive the expressions for the velocity and acceleration of the particle, and make plots of the position, velocity, and acceleration as a function of time for $0 \le t \le 7$ s. Use the `subplot` command to make the three plots on the same page with the plot of the position on the top, the velocity at the middle, and the acceleration at the bottom. Label the axes appropriately with the correct units.

5.

Define a user-defined function that described by the expression:

$$\sin(c \cdot x) \cdot e^{-b \cdot y},$$

Use the user-defined function to plot the expression for x **or** y**, were:**

$-36 \le x \le 36$; $y = x$; $c = 0.05$; $b = 3$

6.

Write a user-defined MATLAB function that calculates the local maximum or minimum of a quadratic function of the form: $f(x) = ax^2 + bx + c$. For the function name and arguments use `[x,y] = maxmin(a,b,c)`. The input arguments are the constants a, b, and c, and the output arguments are the coordinates x and y of the maximum or the minimum.

Use the function to determine the maximum or minimum of the following functions: *

a) $f(x) = 3x^2 - 18x + 48$

b) $f(x) = -5x^2 + 10x - 3$

***The function does not need to determine whether it is a maximum or minimum, only the coordinates of the local extremum.**

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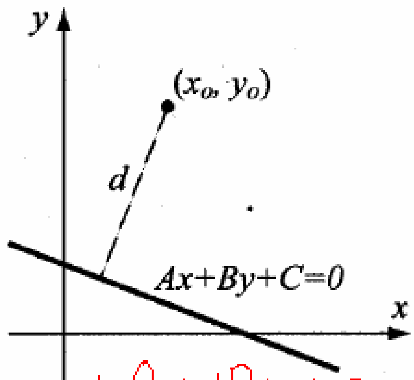
7.

The standard form of the equation of a straight line in the *x*-*y* plane is: $Ax + By + C = 0$, and a point in the plane is defined by its coordinates (x_o, y_o).

Write a user-defined MATLAB function that determines the distance between a point and a straight line in the *x*-*y* plane. For the function name and arguments use:
`d = PtoLdist(xo,yo,A,B,C)`
where the input arguments are the coordinates of the point and the three constants of the equation of the line. The output argument is the distance. Use the function to determine the distance for the following cases:



$$d = \left| \frac{Ax_o + By_o + C}{\sqrt{A^2+B^2}} \right|$$

a) Point: (2, –4), line: $-2x + 3.5y - 6 = 0$.

b) Point: (11, 2), line: $y = -2x + 6$, (note that the equation has the slope intercept form).

8.

Write a user-defined function (name it **`FtoC`**) that converts temperature in Fahrenheit degrees (°F) to temperature in Celsius degrees (°C). Add “help” to function.

The average temperatures in Tel-Aviv in each month are given in Fahrenheit degrees. In your script file:

a) Call the help of the function.
b) Use the function **`FtoC`** to convert the high and low temperatures to Celsius.
c) Plot the temperatures vs. months in one figure: Use blue solid curve to plot the low values and red solid curve to plot the high values.
d) Add grid, title, legend and label the axes.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Low [°F]	49	48	51	54	63	67	70	72	69	59	54	47
High [°F]	65	66	69	72	77	83	86	86	89	83	76	66

9.

Write a user-defined MATLAB function that gives a random integer number within a range between two numbers. For the function name and arguments use `n = randint(a,b)`, where the two input arguments `a` and `b` are the two numbers and the output argument `n` is the random number.

Use the function in the Command Window for the following:

a) Generate a random number between 1 and 49.

b) Generate a random number between –35 and –2.

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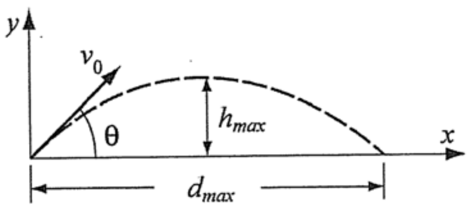
10.

Create a function file that calculates the trajectory of a projectile. The inputs to the function are the initial velocity and the angle at which the projectile is fired. The outputs from the function are the maximum height and distance. In addition, the function generates a plot of the trajectory. Use the function to calculate the trajectory of a projectile that is fired at a velocity of 230 m/s at an angle of 39°.



Kinematics Reminder:

The motion of a projectile can be analyzed by considering the horizontal and vertical components. The initial velocity v_0 can be resolved into horizontal and vertical components:

$$v_{0x} = v_0 \cos(\theta) \quad \text{and} \quad v_{0y} = v_0 \sin(\theta)$$

In the vertical direction the velocity and position of the projectile are given by:

$$v_y = v_{0y} - gt \quad \text{and} \quad y = v_{0y}t - \frac{1}{2}gt^2$$

The time it takes the projectile to reach the highest point $(v_y = 0)$ and the corresponding height are given by:

$$t_{hmax} = \frac{v_{0y}}{g} \quad \text{and} \quad h_{max} = \frac{v_{0y}^2}{2g}$$

The total flying time is twice the time it takes the projectile to reach the highest point, $t_{tot} = 2t_{hmax}$. In the horizontal direction the velocity is constant, and the position of the projectile is given by:

$$x = v_{0x}t$$