Problem Set 8: Part 2

Problem 1

The force F (in N) acting between a particle with a charge q and a round disk with a radius R and a charge Q is given by the equation:

$$F = \frac{Qqz}{2\epsilon_0}\left(1 = \frac{z}{\sqrt{z^2 + R^2}}\right)$$

where $\epsilon_o = 0.885 \times 10^{-12} C^2/(Nm^2)$ is the permittivity constant and z is the distance to the particle. Consider the case where $Q = 9.4x10^{-6}C$, $q = 2.4 \times 10^{-5}C$, and $R = 0.1m$. Make a plot of F as a function of z for $0 \leq z \leq 0.3$ m. Use MATLAB's built-in function *max* to find the maximum value of $F$and the corresponding distance z.

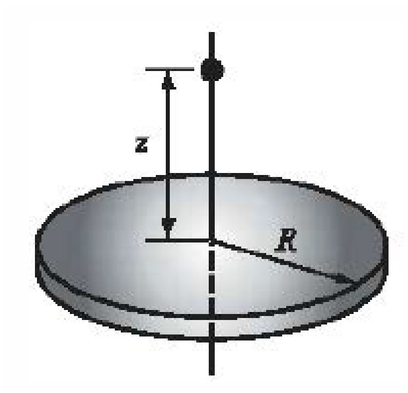

Figure 1:

Problem 2

A railroad bumper is designed to slow down a rapidly moving railroad car. After a 20,000 kg railroad car traveling at $20^{m}/_{s}$ engages the bumper, its displacement x (in meters) and velocity v (in mls) as a function of timet (in seconds) is given by:

$$x(t) = 4.219(e^{-1.58t} - e^{-6 \cdot 321t})$$

and

$$v(t) = 26.67e^{-6.32t} - 6.67e^{-1.58t}$$

Plot the displacement and the velocity as a fimction of time for $0 \leq t \leq 4\,s$ Make two plots on one page.

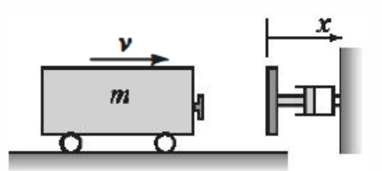

Figure 2:

Problem 3

When monochromatic light passes through a narrow slit it produces on a screen a diffraction pattern consisting of bright and dark fringes. The intensity of the bright fringes I, as a function of θ can be calculated by
$I = I_{max}\left(\frac{sin\alpha}{\alpha}\right)^2$where $\alpha = \frac{\pi a}{\lambda}sin\theta$
where λ is the light wavelength and a is the width of the slit. Plot the relative intensity $^{I}/_{I_{max}}$ as a fimction of θ for $-20° \leq \theta \leq 20°$. Make one plot that contains three graphs for the cases $a = 10\lambda$, $a = 5\lambda$, $a = \lambda$. Label the axes, and display a legend.

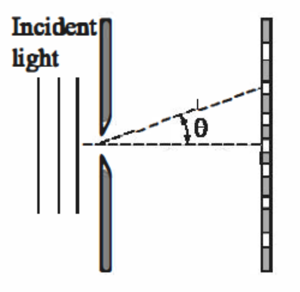

Figure 3:

Problem 4

The Taylor series for $cos(x)$ is:

$$1 - \frac{x^2}{2!} + \frac{x^4}{4!} + \frac{x^6}{6!} + \frac{x^8}{8!} - \frac{x^{10}}{10!} + \ldots$$

Plot the figure below, which shows, for $-2\pi \leq x \leq 2\pi$, the graph of the function *cos(x)* and graphs of the Taylor series expansion of *cos(x)* with two, four, and six terms. Label the axes and display a legend.

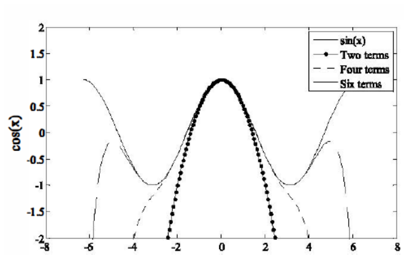

Figure 4:

Problem 5

The shape of the pretzel shown is given by the following parametric equations:
$x = (3.3 - 0.4t^2)sin(t)$ $y = (2.5 - 0.3t^2)cos(t)$
where $-4 \leq t \leq 3$. Make a plot of the pretzel.

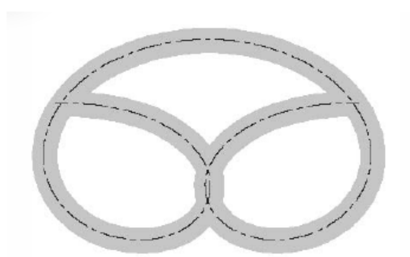

Figure 5:

Problem 6

The position as a function of time of a squirrel running on a grass field is given in polar coordinates by: $r(t) = 25 + 30[1 - e^{sin(0.07t)}]\ m\ \theta(t) = 2\pi(1 - e^{-0.2t})$ Plot the trajectory (position) of the squirrel for $0 \leq t \leq 20\, s$.

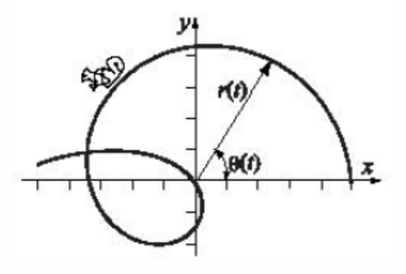

Figure 6:

Problem 7

A bandpass filter passes signals with frequencies that are within a certain range. In this filter the ratio of the magnitudes of the voltages is given by
$RV = \left|\frac{Vo}{V_i}\right| = \frac{\omega RC}{\sqrt{(1-\omega^2 LC)^2+(\omega RC)^2}}$
where ω is the frequency of the input signal. Given $R = 200\Omega$, $L = 8mH$, and $C = 5\mu F$, make two plots of RV as a function of ω for $10 \leq \omega \leq 500000$. In the first plot use linear scale for both axis, and in the second plot use logarithmic scale for the horizontal (m) axis, and linear scale for the vertical axis. Which plot provides a better illustration of the filter?

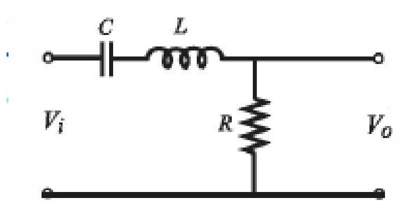

Figure 7: