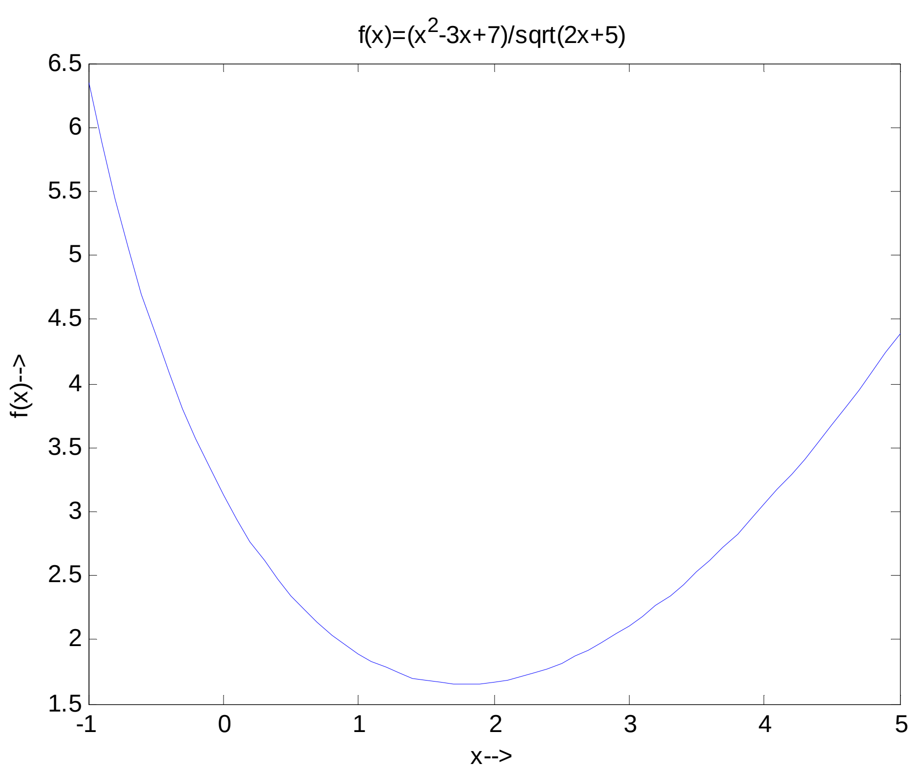
Chapter 5
Solved Problems

Problem 1

Script file:

```
clear, clc
%.1 is usually a good interval to start with - then adjust if necessary
x=-1:.1:5;
f=(x.^2-3*x+7)./sqrt(2*x+5);
plot(x,f)
%note all plot annotation functions will accept some basic tex syntax
title('f(x)=(x^2-3x+7)/sqrt(2x+5)')
%and latex commands for fancier
%title('$$f(x)=\frac{x^2-3x+7}{\sqrt{2x+5}}$$','Interpreter','latex')
xlabel('x-->')
ylabel('f(x)-->')
```

Figure Window:

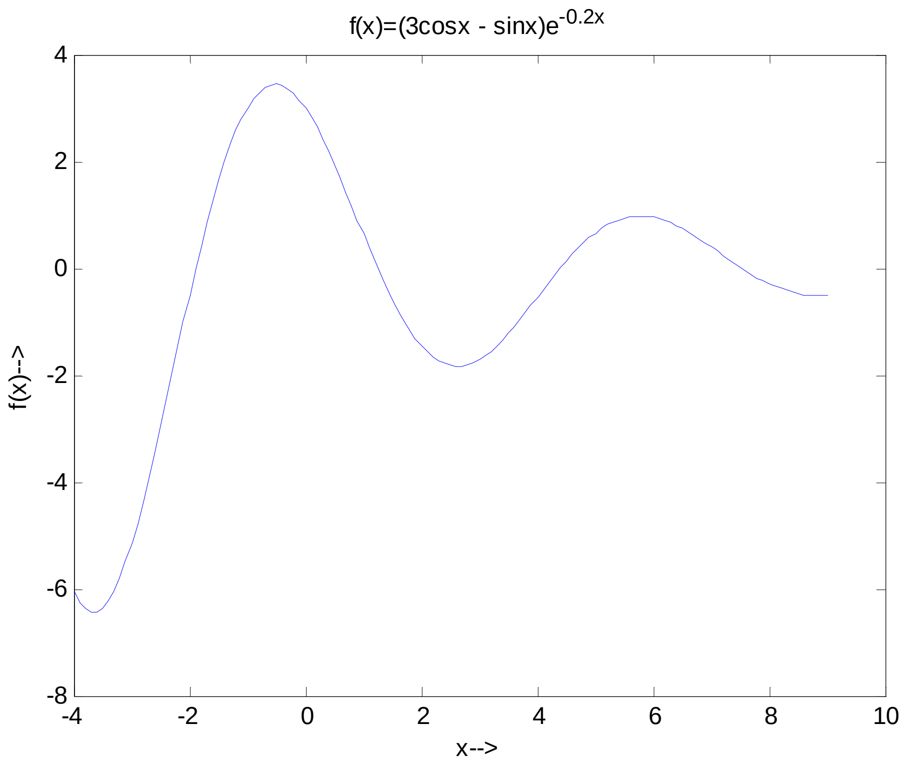


Problem 2

Script file:

```
x=-4:.1:9;
f=(3*cos(x)-sin(x)).*exp(-0.2*x);
plot(x,f)
title('f(x)=(3cosx - sinx)e^{-0.2x}')
xlabel('x-->')
ylabel('f(x)-->')
```

Figure Window:

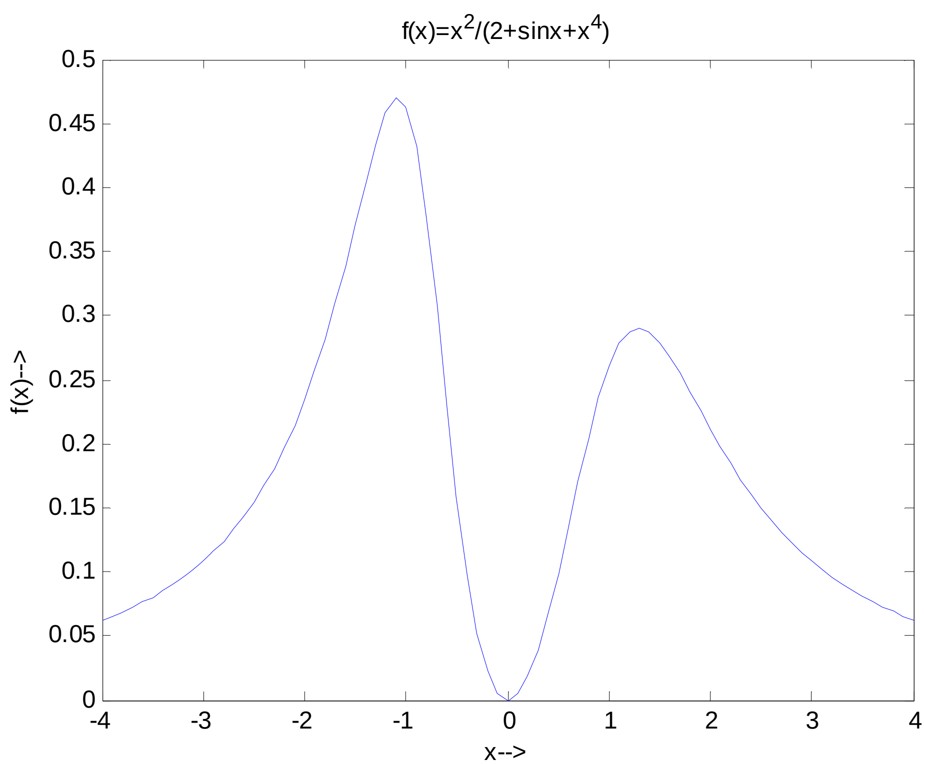


Problem 3

Script file:

```
clear, clc
x=-4:.1:4;
f=x.^2./(2+sin(x)+x.^4);
plot(x,f)
title('f(x)=x^2/(2+sinx+x^4)')
xlabel('x-->')
ylabel('f(x)-->')
```

Figure Window:

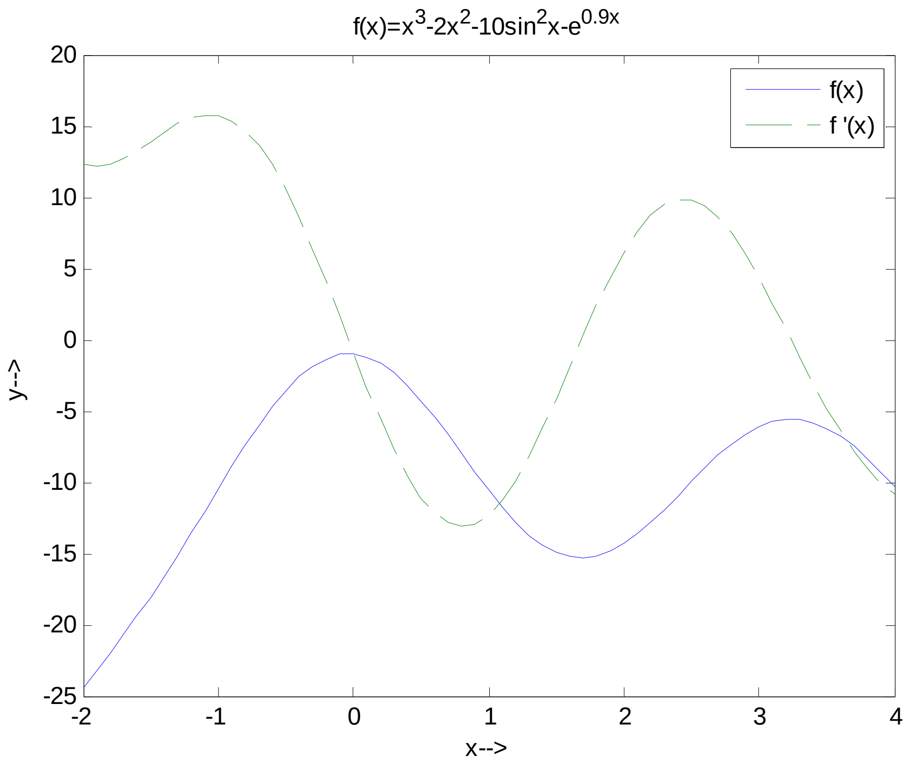


Problem 4

Script file:

```
clear, clc
x=-2:.1:4;
f=x.^3 - 2*x.^2-10*sin(x).^2-exp(0.9*x);
fp=3*x.^2-4*x-20*sin(x).*cos(x)-0.9*exp(0.9*x);
plot(x,f,x,fp,'--')
title('f(x)=x^3-2x^2-10sin^2x-e^{0.9x}')
legend('f(x)','f ''(x)')
xlabel('x-->')
ylabel('y-->')
```

Figure Window:

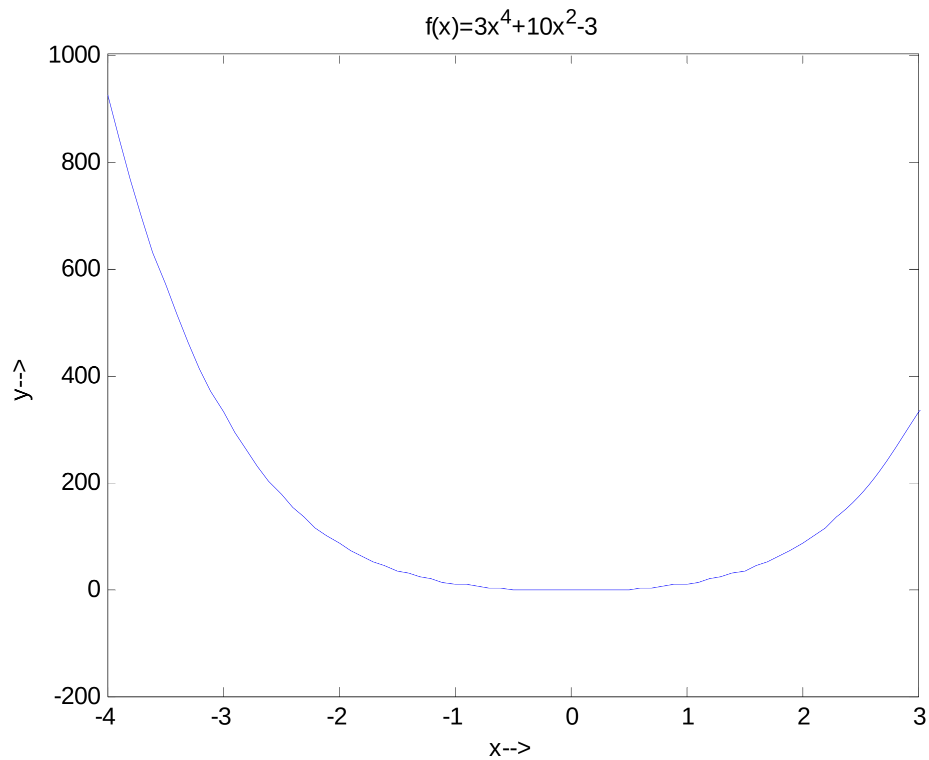


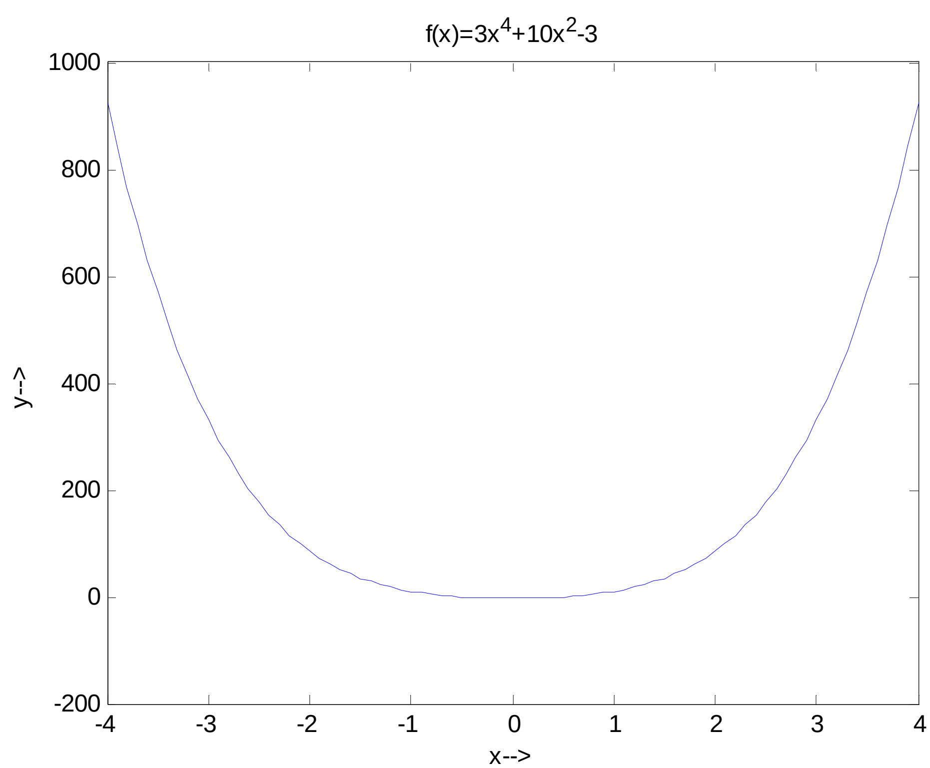
Problem 5

Script file:

```
x=-4:.1:4;
f=3*x.^4+10*x.^2-3;
figure(1)
plot(x,f)
axis([-4 3 -200 1000])
title('f(x)=3x^4+10x^2-3')
xlabel('x-->')
ylabel('y-->')
figure(2)
plot(x,f)
title('f(x)=3x^4+10x^2-3')
xlabel('x-->')
ylabel('y-->')
```

Figure Windows:



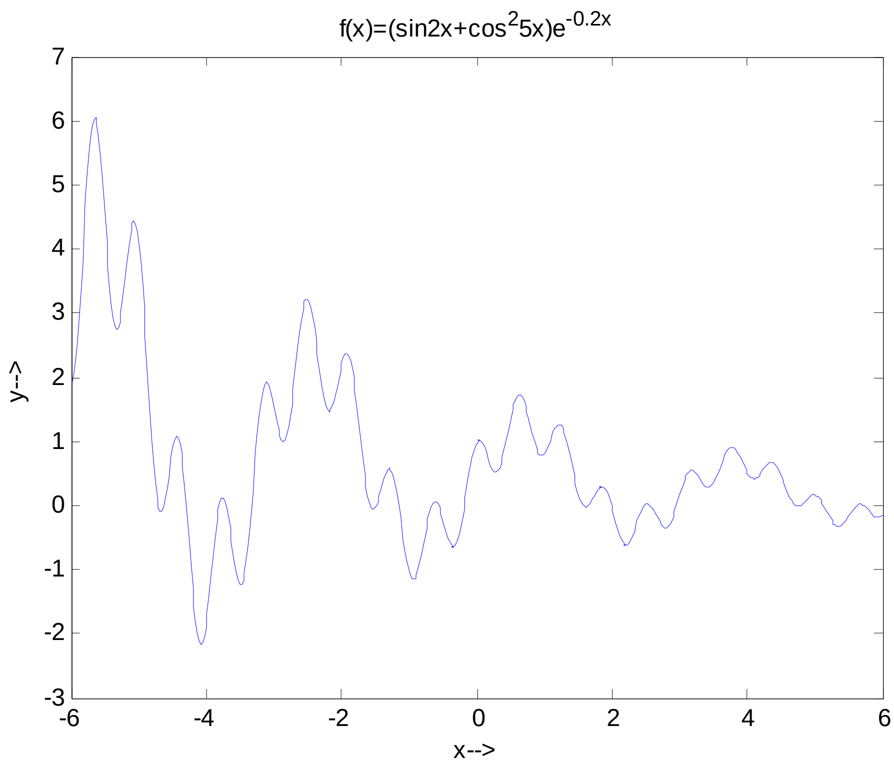


Problem 6

Script file:

```
clear, clc
fplot('(sin(2*x)+cos(5*x)^2)*exp(-0.2*x)',[-6 6])
title('f(x)=(sin2x+cos^25x)e^{-0.2x}')
xlabel('x-->')
ylabel('y-->')
```

Figure Window:

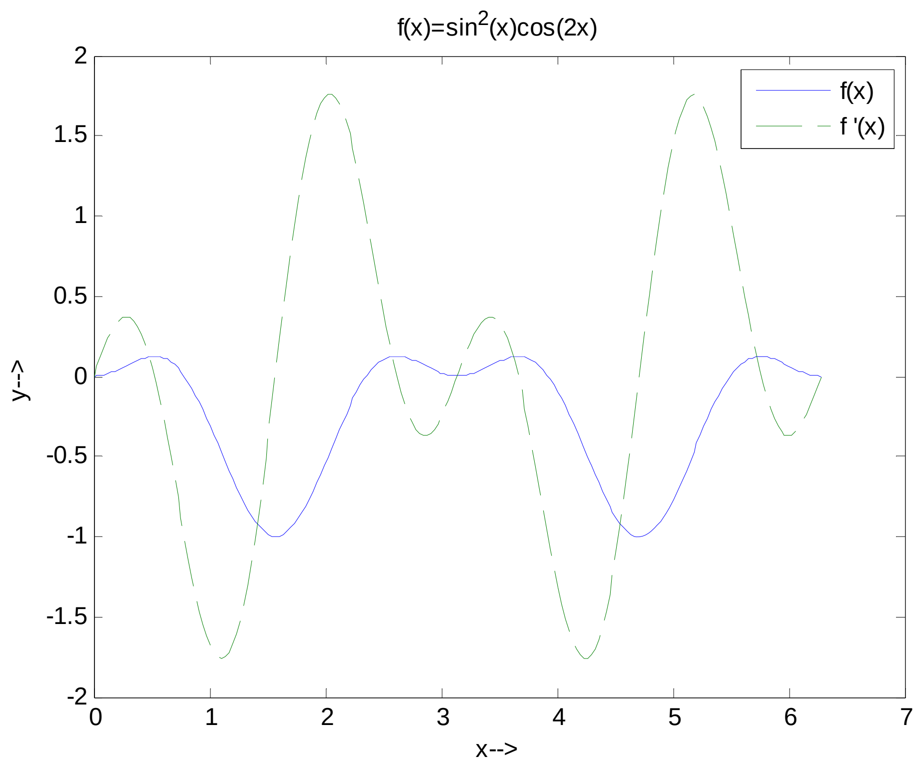


Problem 7

Script file:

```
clear, clc
x=linspace(0,2*pi,200);
f=sin(x).^2.*cos(2*x);
fp=2*sin(x).*cos(x).*cos(2*x)-2*sin(x).^2.*sin(2*x);
plot(x,f,x,fp,'--')
title('f(x)=sin^2(x)cos(2x)')
legend('f(x)','f ''(x)')
xlabel('x-->')
ylabel('y-->')
```

Figure Window:

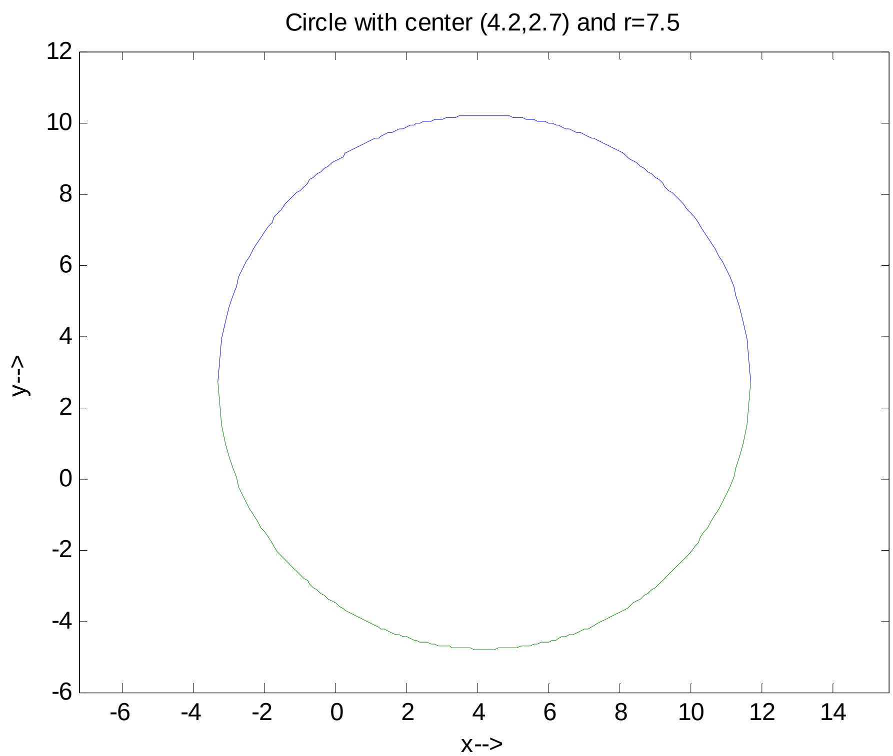


Problem 8

Script file:

```
x=(4.2-7.5):.1:(4.2+7.5);
y1=2.7+sqrt(7.5^2-(x-4.2).^2);
y2=2.7-sqrt(7.5^2-(x-4.2).^2);
plot(x,y1,x,y2)
axis([-4 12 -6 12])
axis equal
title('Circle with center (4.2,2.7) and r=7.5')
xlabel('x-->')
ylabel('y-->')
```

Figure Window:

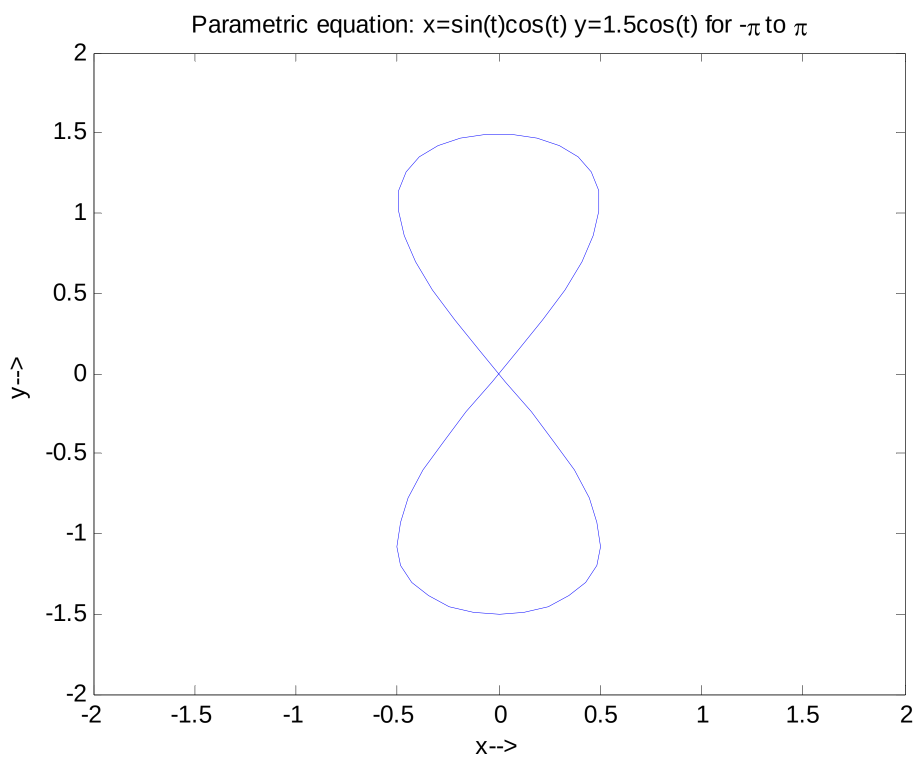


Problem 9

Script file:

```
clear, clc
t=linspace(-pi,pi,50);
x=sin(t).*cos(t); y=1.5*cos(t);
plot(x,y)
axis([-2 2 -2 2])
title('Parametric equation: x=sin(t)cos(t) y=1.5cos(t) for -\pi to \pi')
xlabel('x-->')
ylabel('y-->')
```

Figure Window:

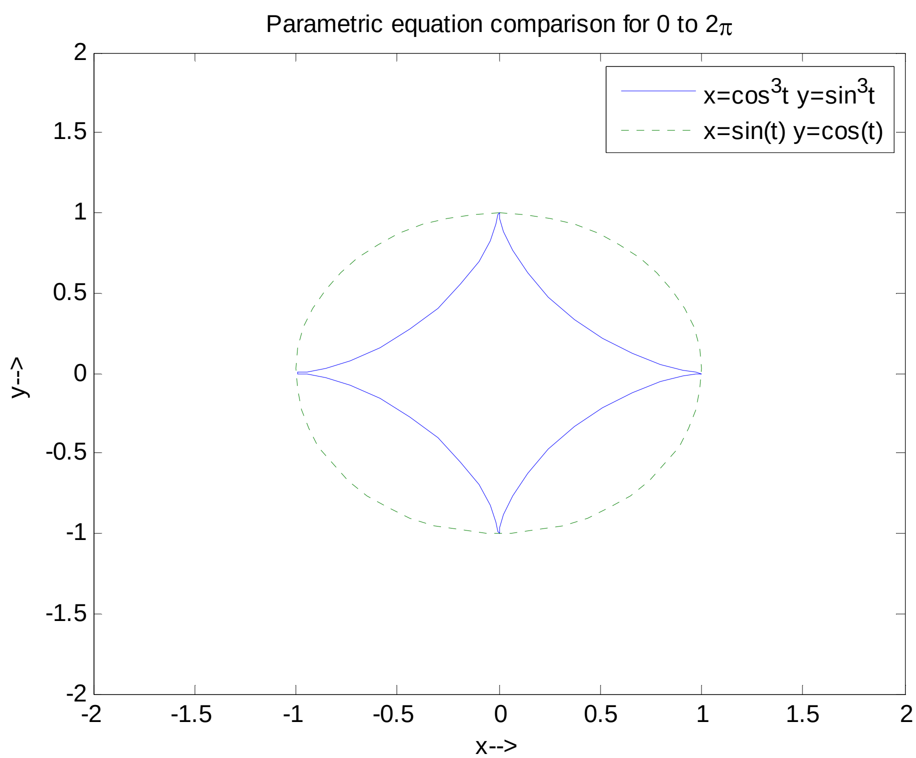


Problem 10

Script file:

```
clear, clc
t=linspace(0,2*pi,50);
x=cos(t).^3; y=sin(t).^3;
u=sin(t); v=cos(t);
plot(x,y,u,v,':')
axis([-2 2 -2 2])
title('Parametric equation comparison for 0 to 2\pi')
legend('x=cos^3t y=sin^3t','x=sin(t) y=cos(t)')
xlabel('x-->')
ylabel('y-->')
```

Figure Window:

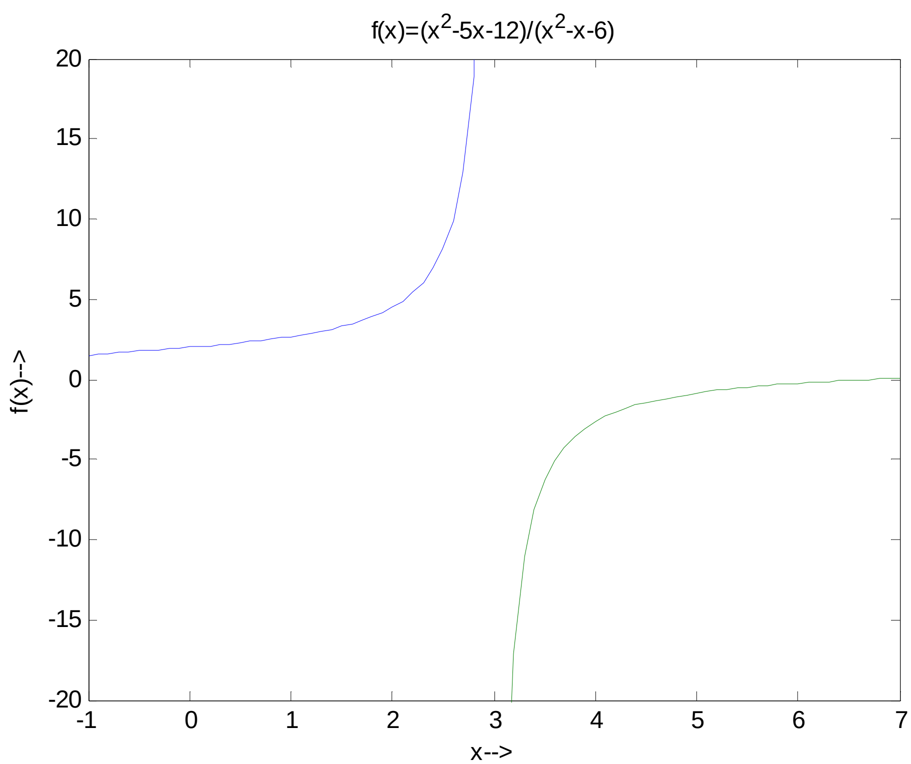


Problem 11

Script file:

```
clear, clc
x1=-1:.1:2.9; x2=3.1:.1:7;
y1=(x1.^2-5*x1-12)./(x1.^2-x1-6);
y2=(x2.^2-5*x2-12)./(x2.^2-x2-6);
plot(x1,y1,x2,y2)
axis([-1 7 -20 20])
title('f(x)=(x^2-5x-12)/(x^2-x-6)')
xlabel('x-->')
ylabel('f(x)-->')
```

Figure Window:

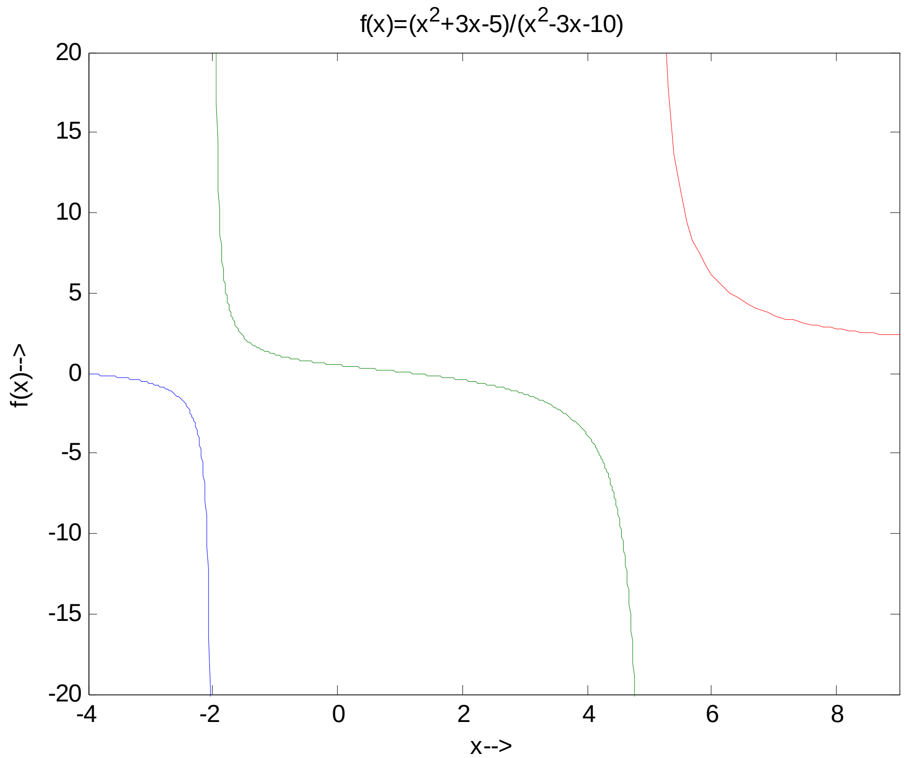


Problem 12

Script file:

```
clear, clc
x1=-4:.01:-2.01; x2=-1.99:.01:4.9; x3=5.1:.1:9;
y1=(x1.^2+3*x1-5)./(x1.^2-3*x1-10);
y2=(x2.^2+3*x2-5)./(x2.^2-3*x2-10);
y3=(x3.^2+3*x3-5)./(x3.^2-3*x3-10);
plot(x1,y1,x2,y2,x3,y3)
axis([-4 9 -20 20])
title('f(x)=(x^2+3x-5)/(x^2-3x-10)')
xlabel('x-->')
ylabel('f(x)-->')
```

Figure Window:

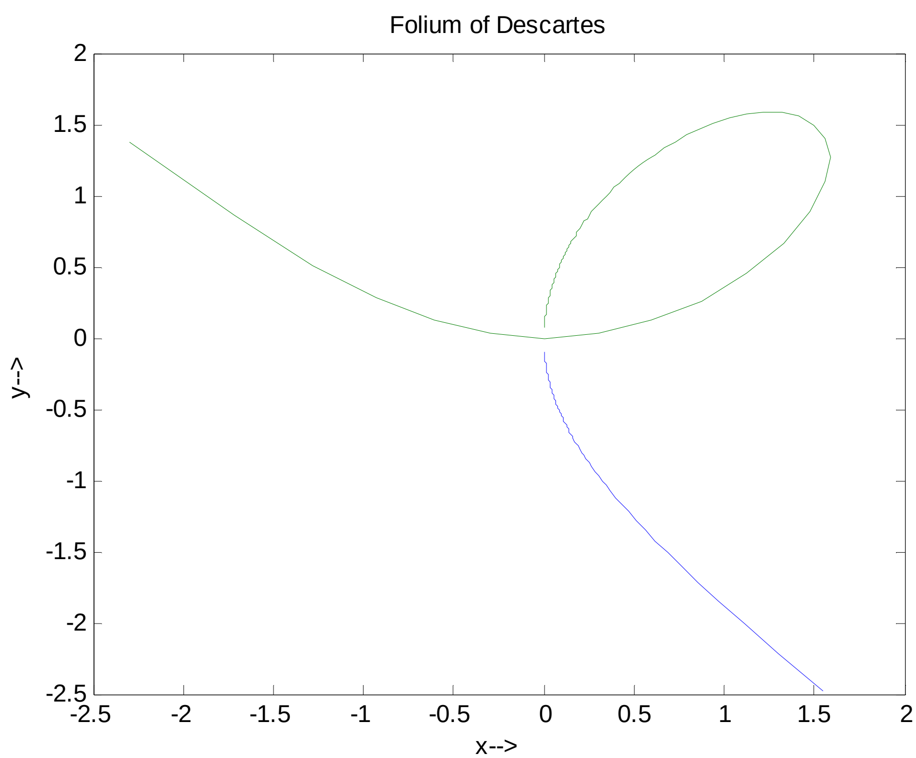


Problem 13

Script file:

```
clear, clc
t1=-30:.1:-1.6; t2=-0.6:.1:40;
x1=3*t1./(1+t1.^3); y1=3*t1.^2./(1+t1.^3);
x2=3*t2./(1+t2.^3); y2=3*t2.^2./(1+t2.^3);
plot(x1,y1,x2,y2)
title('Folium of Descartes')
xlabel('x-->')
ylabel('y-->')
```

Figure Window:

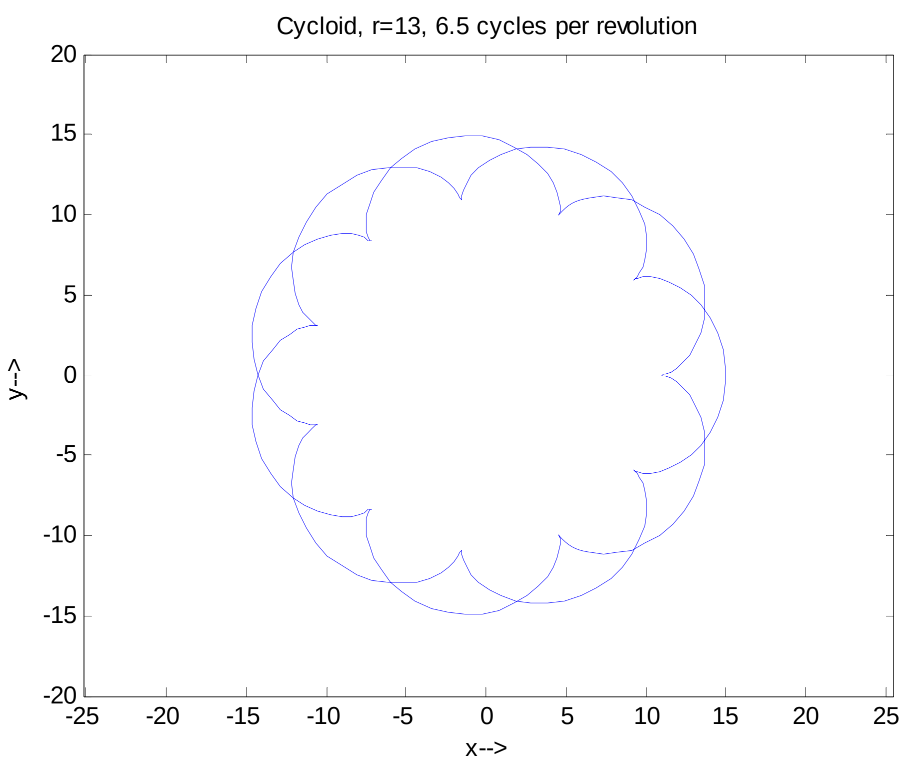


Problem 14

Script file:

```
clear, clc
t=linspace(0,4*pi,300);
x=13*cos(t)-2*cos(6.5*t); y=13*sin(t)-2*sin(6.5*t);
plot(x,y)
axis([-20 20 -20 20])
axis equal
title('Cycloid, r=13, 6.5 cycles per revolution')
xlabel('x-->')
ylabel('y-->')
```

Figure Window:

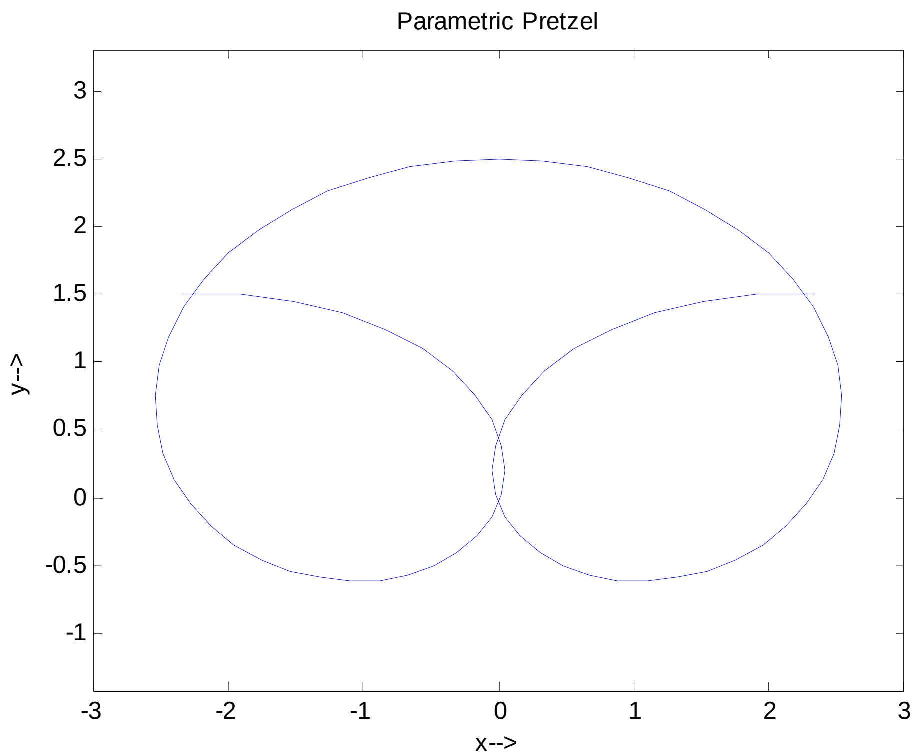


Problem 15

Script file:

```
clear, clc
t=-4:.1:4;
x=(3.3-0.4*t.^2).*sin(t); y=(2.5-0.3*t.^2).*cos(t);
plot(x,y)
axis([-3 3 -1 3])
axis equal
title('Parametric Pretzel')
xlabel('x-->')
ylabel('y-->')
```

Figure Window:

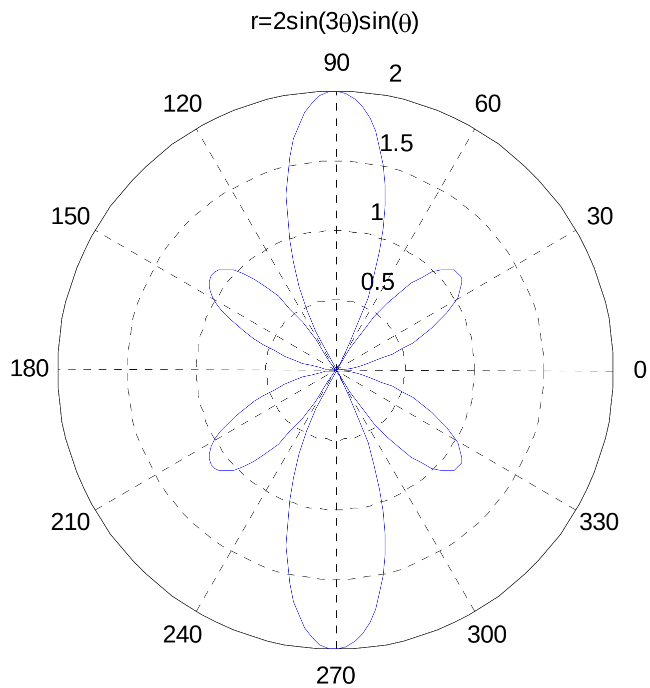


Problem 16

Script file:

```
clear, clc
t=-4:.1:4;
theta=linspace(0,2*pi,200)
r=2*sin(3*theta).*sin(theta);
polar(theta,r)
title('r=2sin(3\theta)sin(\theta)')
```

Figure Window:

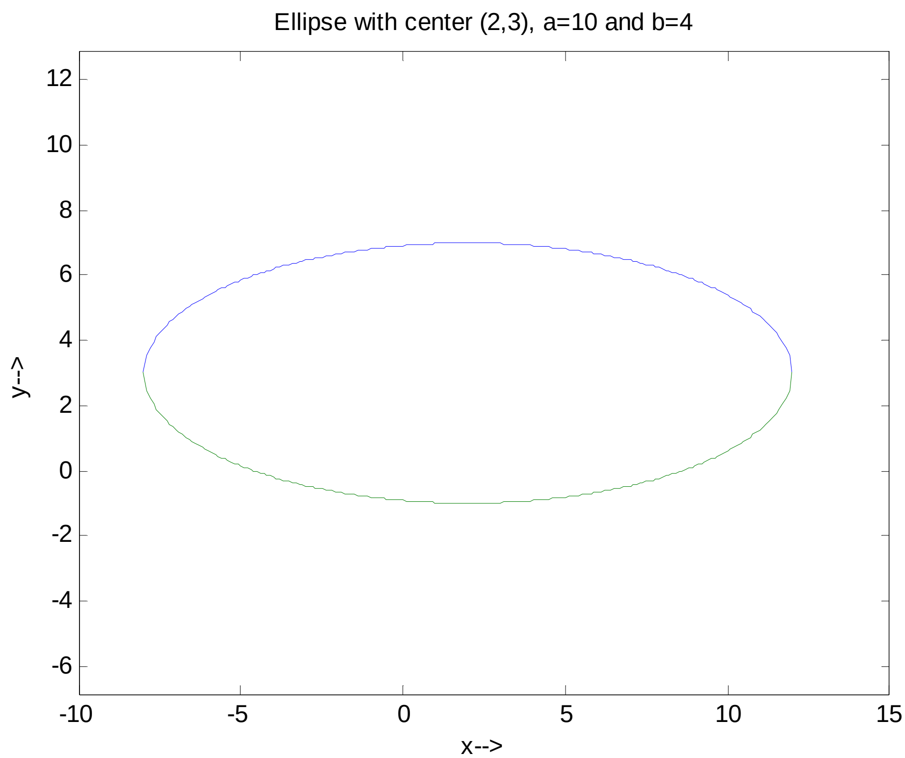


Problem 17

Script file:

```
clear, clc
x=-8:.1:12;
y1=3+sqrt(16-4*(x-2).^2/25);
y2=3-sqrt(16-4*(x-2).^2/25);
plot(x,y1,x,y2)
axis([-10 15 -5 5])
axis equal
title('Ellipse with center (2,3), a=10 and b=4')
xlabel('x-->')
ylabel('y-->')
```

Figure Window:

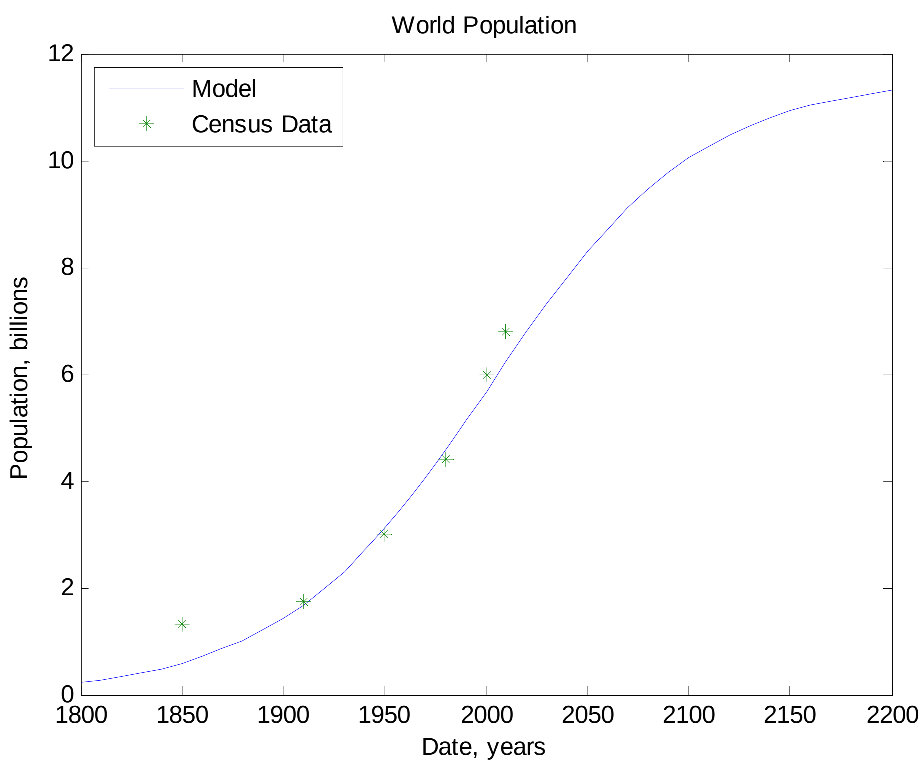


Problem 18

Script file:

```
clear, clc
year=[1850 1910 1950 1980 2000 2010];
pop=[1.3 1.75 3 4.4 6 6.8];
t=-50:10:350;
P=11.55./(1+18.7*exp(-0.0193*t));
plot(t+1850,P,year,pop,'*')
title('World Population')
legend('Model','Census Data','location','NorthWest')
xlabel('Date, years')
ylabel('Population, billions')
```

Figure Window:



Problem 19

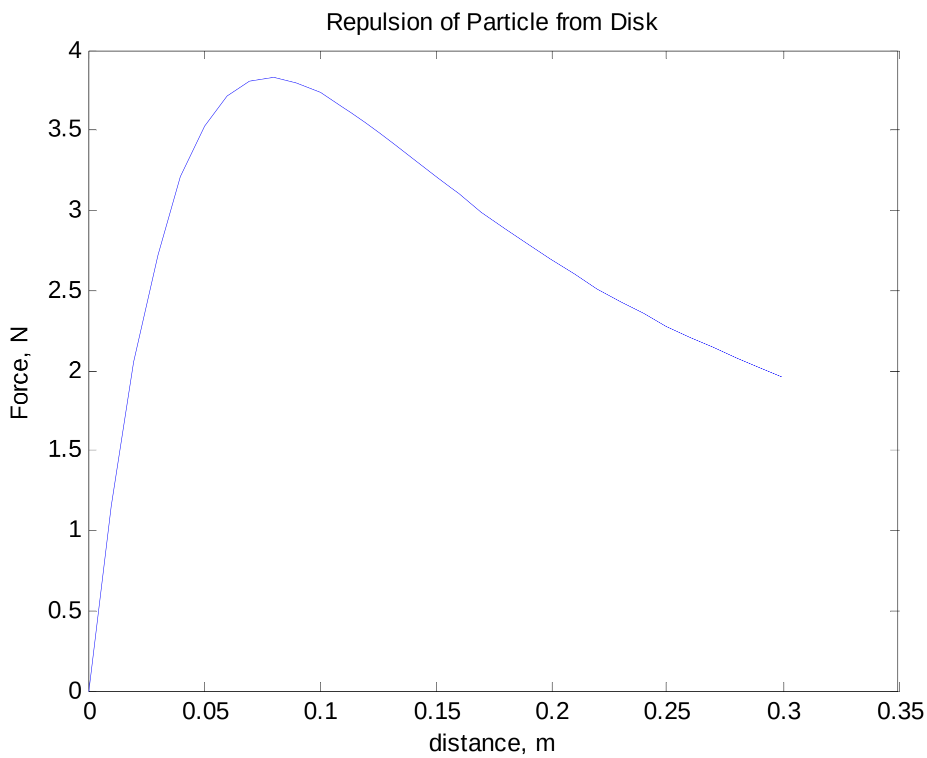
Script file:

```
e0=0.885e-12; Q=9.4e-6; q=2.4e-5; R=0.1;
z=0:.01:.3;
F=Q*q*z.*(1-z./sqrt(z.^2+R^2))/(2*e0);
plot(z,F)
title('Repulsion of Particle from Disk')
xlabel('distance, m')
ylabel('Force, N')
[Fmax indx] = max(F);
fprintf('The maximum repulsion (%.2fN) occurs at a distance of %.2f m\n',...
    Fmax,z(indx))
```

Command Window:

The maximum repulsion (3.83N) occurs at a distance of 0.08 m

Figure Window:

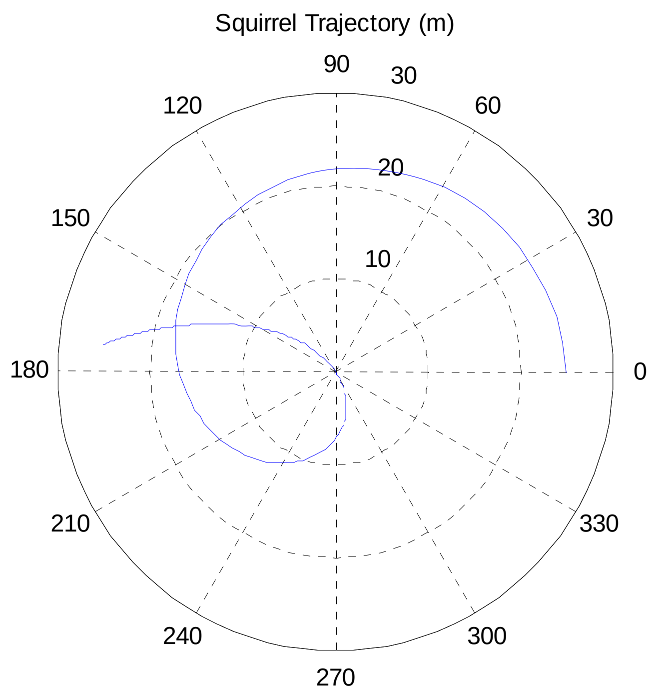


Problem 20

Script file:

```
clear, clc
t=0:.1:20;
r=25+30*(1-exp(sin(0.07*t)));
theta=2*pi*(1-exp(-0.2*t));
polar(theta,r)
title('Squirrel Trajectory (m)')
```

Figure Window:

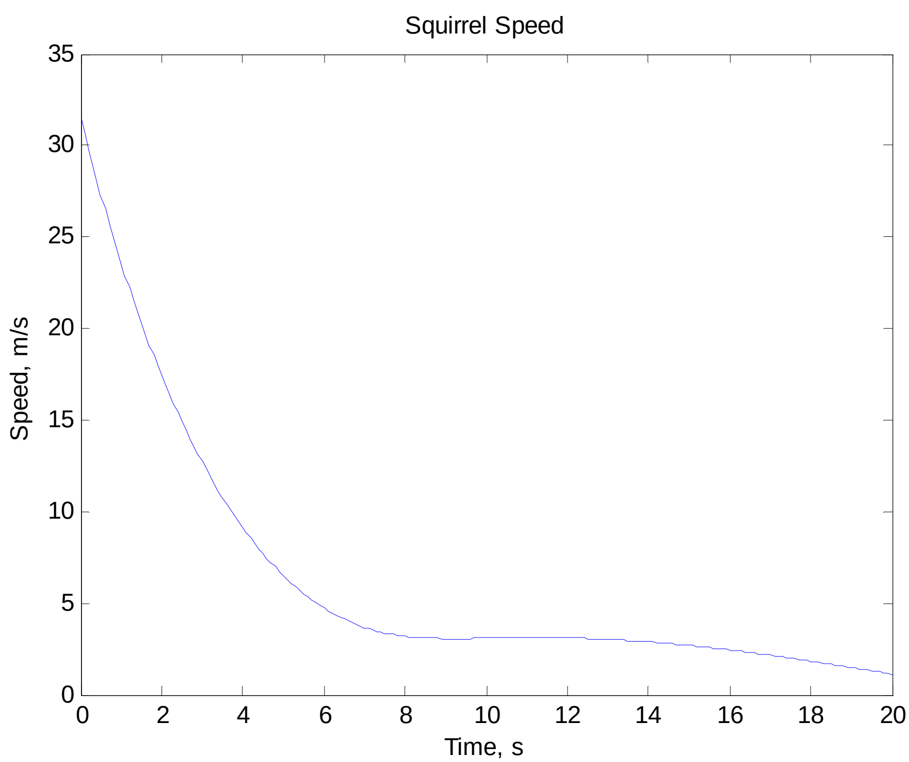


Problem 21

Script file:

```
clear, clc
t=0:.1:20;
r=25+30*(1-exp(sin(0.07*t)));
vr=-30*0.07*exp(sin(0.07*t)).*cos(0.07*t);
vt=2*pi*0.2*r.*exp(-0.2*t);
v=sqrt(vr.^2+vt.^2);
plot(t,v)
title('Squirrel Speed')
xlabel('Time, s')
ylabel('Speed, m/s')
```

Figure Window:

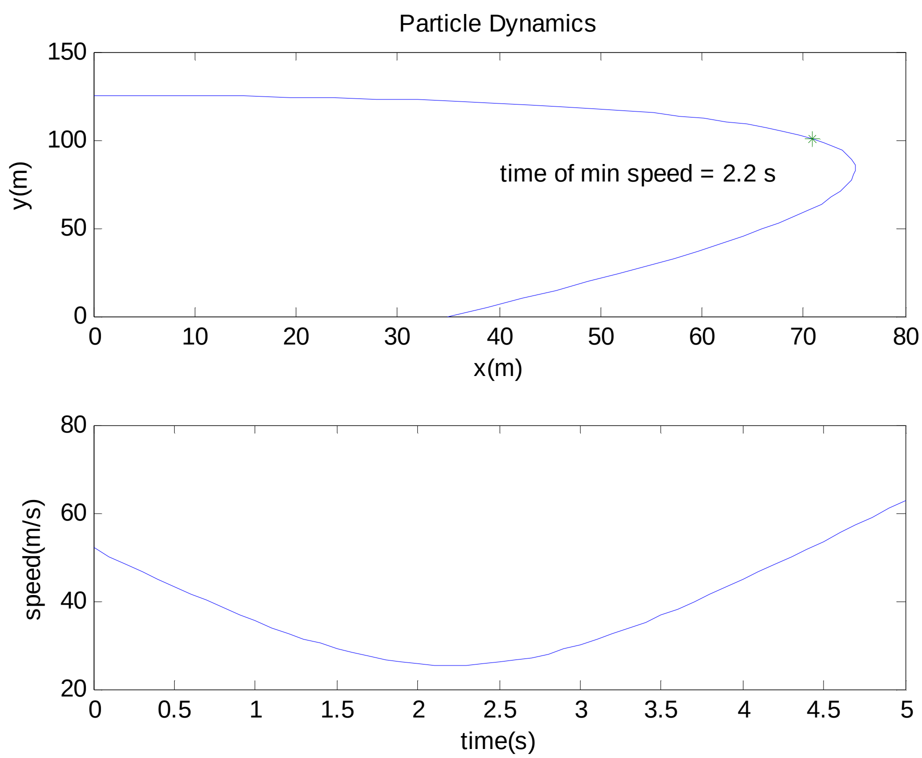


Problem 22

Script file:

```
t=0:.1:5;
x=52*t-9*t.^2; y=125-5*t.^2;
vx=52-18*t; vy=-10*t;
v=sqrt(vx.^2+vy.^2);
[vmin indx]=min(v);
tmin=t(indx);
subplot(2,1,1)
plot(x,y,x(indx),y(indx),'*')
title('Particle Dynamics')
xlabel('x(m)')
ylabel('y(m)')
text(40,80,['time of min speed = ',num2str(tmin,'%.1f'),' s'])
subplot(2,1,2)
plot(t,v)
xlabel('time(s)')
ylabel('speed(m/s)')
```

Figure Window:

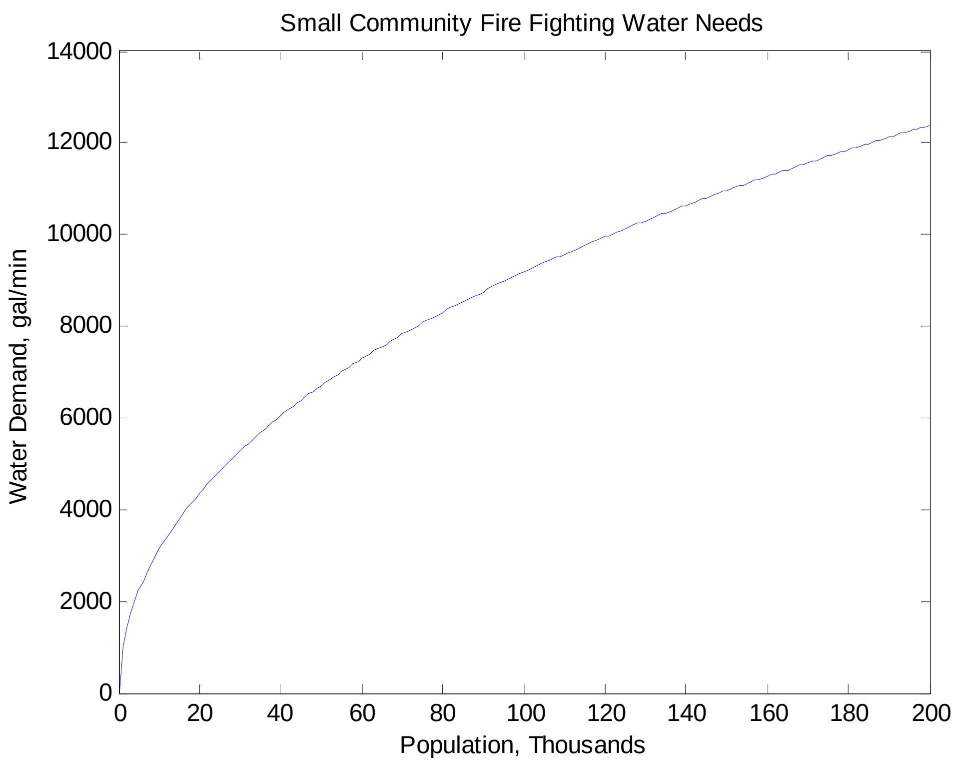


Problem 23

Script file:

```
clear, clc
P=0:200;
Q=1020*sqrt(P).*(1-0.01*sqrt(P));
plot(P,Q)
title('Small Community Fire Fighting Water Needs')
xlabel('Population, Thousands')
ylabel('Water Demand, gal/min')
```

Figure Window:

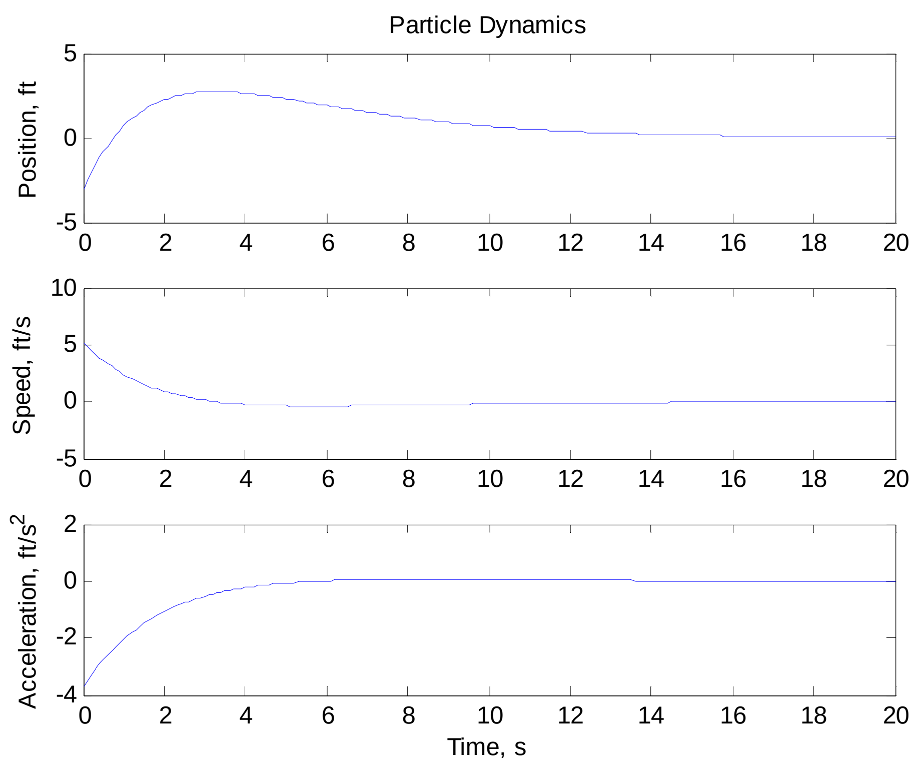


Problem 24

Script file:

```
clear, clc
t=0:.1:20;
x=(-3+4*t).*exp(-0.4*t);
v=4*exp(-0.4*t)-0.4*(-3+4*t).*exp(-0.4*t);
a=-1.6*exp(-0.4*t)-1.6*exp(-0.4*t)+0.16*(-3+4*t).*exp(-0.4*t);
subplot(3,1,1)
plot(t,x)
title('Particle Dynamics')
ylabel('Position, ft')
subplot(3,1,2)
plot(t,v)
ylabel('Speed, ft/s')
subplot(3,1,3)
plot(t,a)
ylabel('Acceleration, ft/s^2')
xlabel('Time, s')
```

Figure Window:

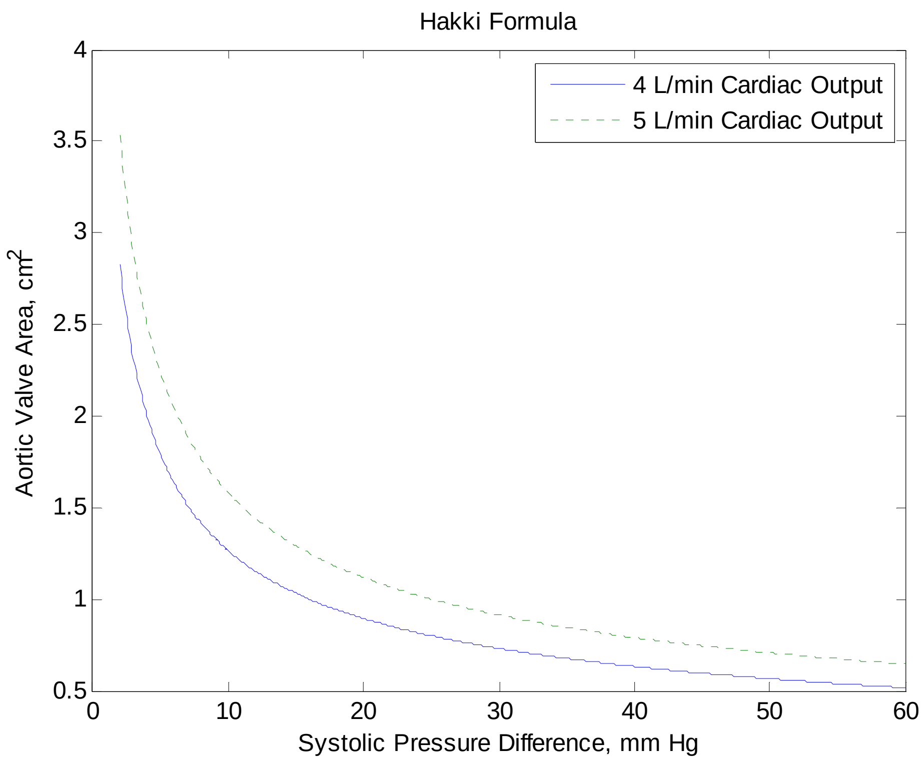


Problem 25

Script file:

```
Q1=4; Q2=5;
PG=2:.1:60;
Av1=Q1./sqrt(PG);
Av2=Q2./sqrt(PG);
plot(PG,Av1,PG,Av2,':')
title('Hakki Formula')
legend('4 L/min Cardiac Output','5 L/min Cardiac Output')
xlabel('Systolic Pressure Difference, mm Hg')
ylabel('Aortic Valve Area, cm^2')
```

Figure Window:

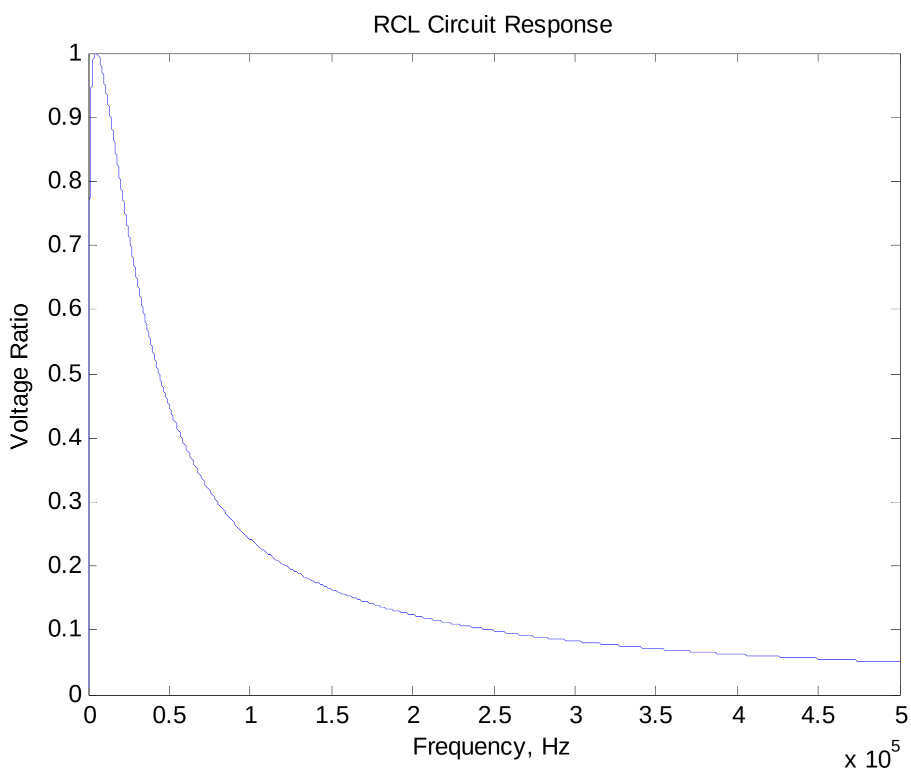


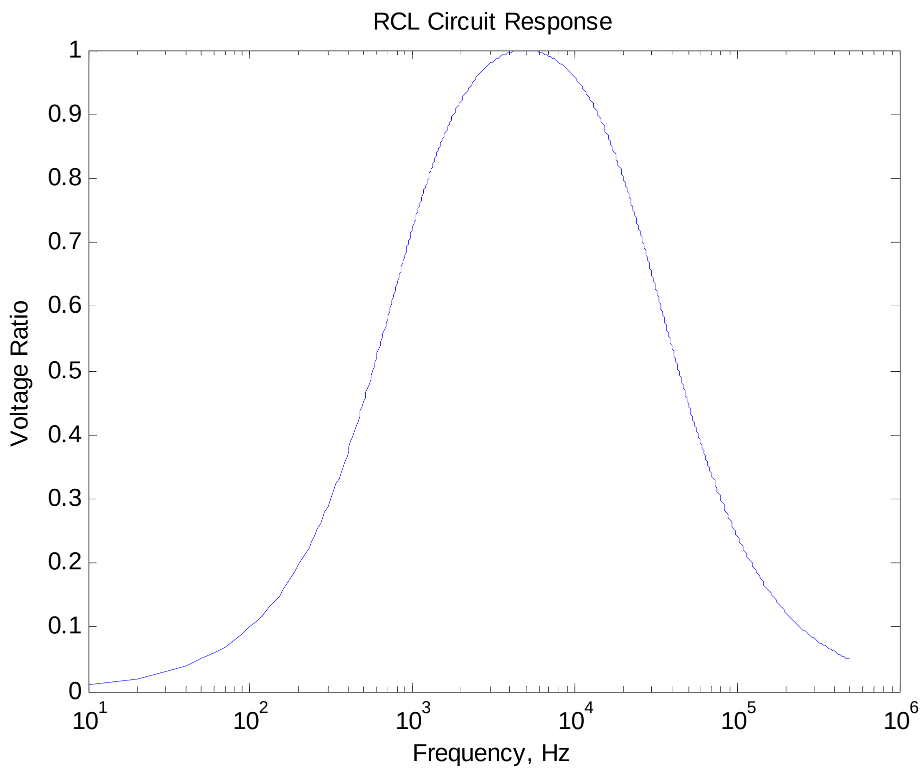
Problem 26

Script file:

```
clear, clc
R=200; L=8e-3; C=5e-6;
omega=10:10:500000;
RV=omega*R*C./sqrt((1-omega.^2*L*C).^2+(omega*R*C).^2);
figure(1)
plot(omega,RV)
title('RCL Circuit Response')
xlabel('Frequency, Hz')
ylabel('Voltage Ratio')
figure(2)
semilogx(omega,RV)
title('RCL Circuit Response')
xlabel('Frequency, Hz')
ylabel('Voltage Ratio')
```

Figure Window:





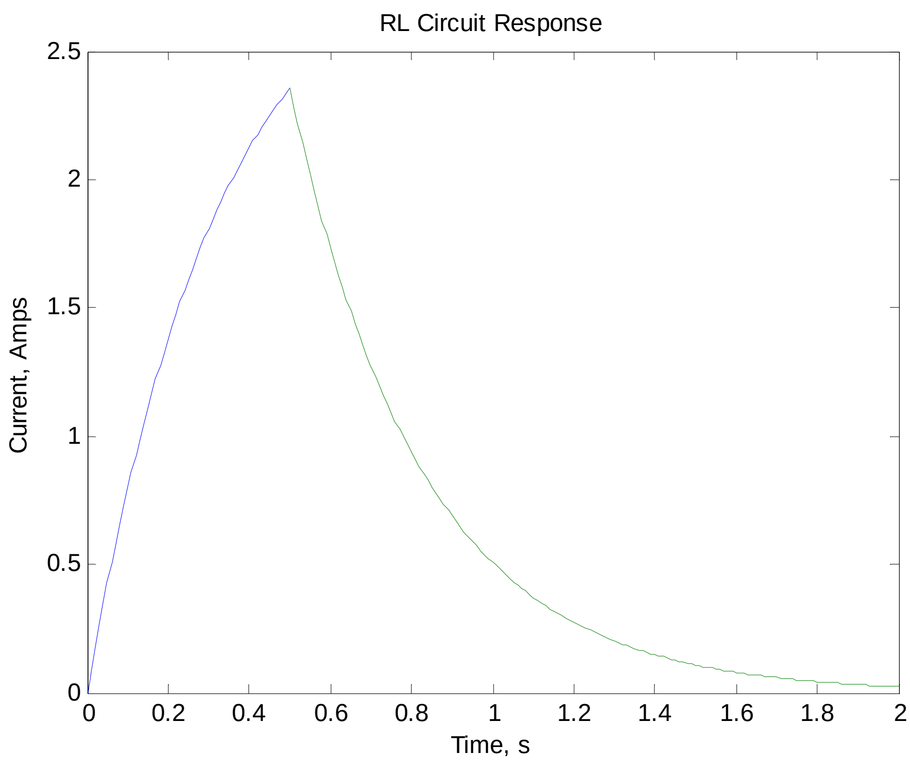
The semi-log plot better shows the response of the filter. The linear plot does not adequately show the suppression of low frequencies.

Problem 27

Script file:

```
clear, clc
V=12; R=4; L=1.3;
t1=0:.01:.5; t2=0.5:.01:2;
i1=V/R*(1-exp(-R*t1/L));
i2=exp(-R*t2/L)*V/R*(exp(0.5*R/L)-1);
plot(t1,i1,t2,i2)
title('RL Circuit Response')
xlabel('Time, s')
ylabel('Current, Amps')
```

Figure Window:

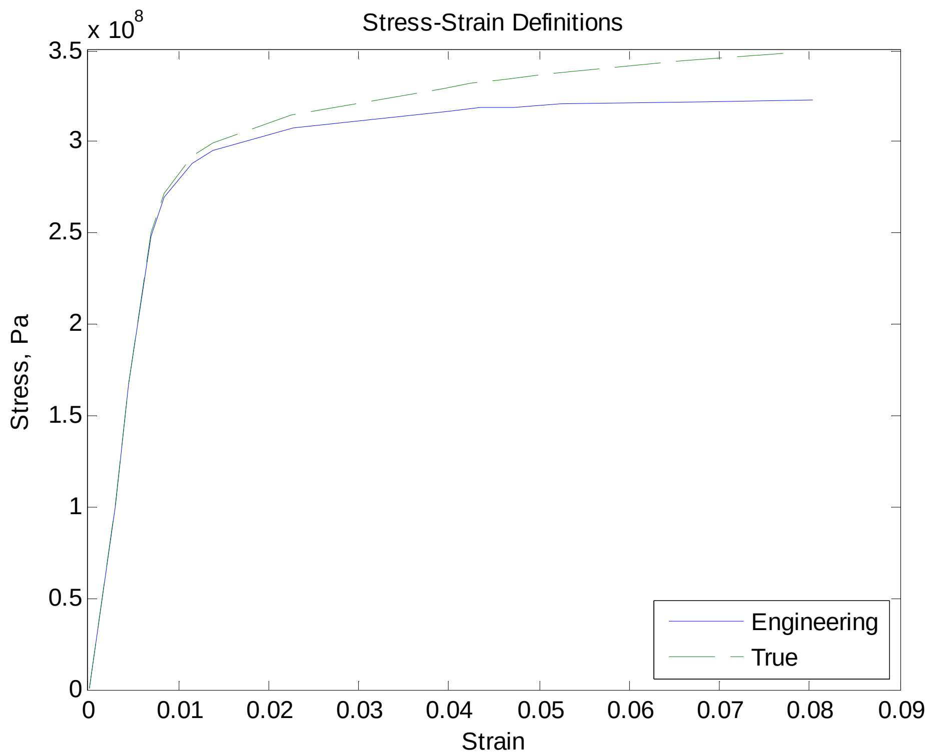


Problem 28

Script file:

```
L0=.0254; r0=.0064; A0=pi*r0^2;
F=[0 13031 21485 31963 34727 37119 37960 39550 ...
    40758 40986 41076 41255 41481 41564];
L=[25.4 25.474 25.515 25.575 25.615 25.693 25.752 25.978 ...
    26.419 26.502 26.600 26.728 27.130 27.441]/1000;
sigmae=F/A0; ee=(L-L0)/L0;
sigmat=F.*L/(A0*L0); et=log(L/L0);
plot(ee,sigmae,et,sigmat,'--')
title('Stress-Strain Definitions')
legend('Engineering','True','location','SouthEast')
xlabel('Strain')
ylabel('Stress, Pa')
```

Figure Window:

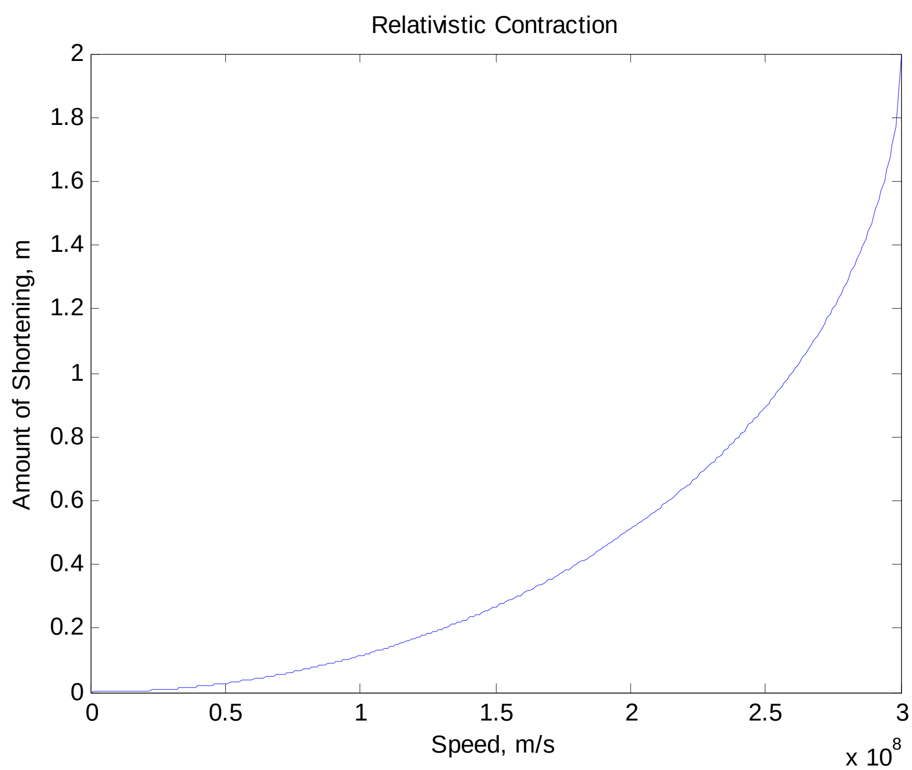


Problem 29

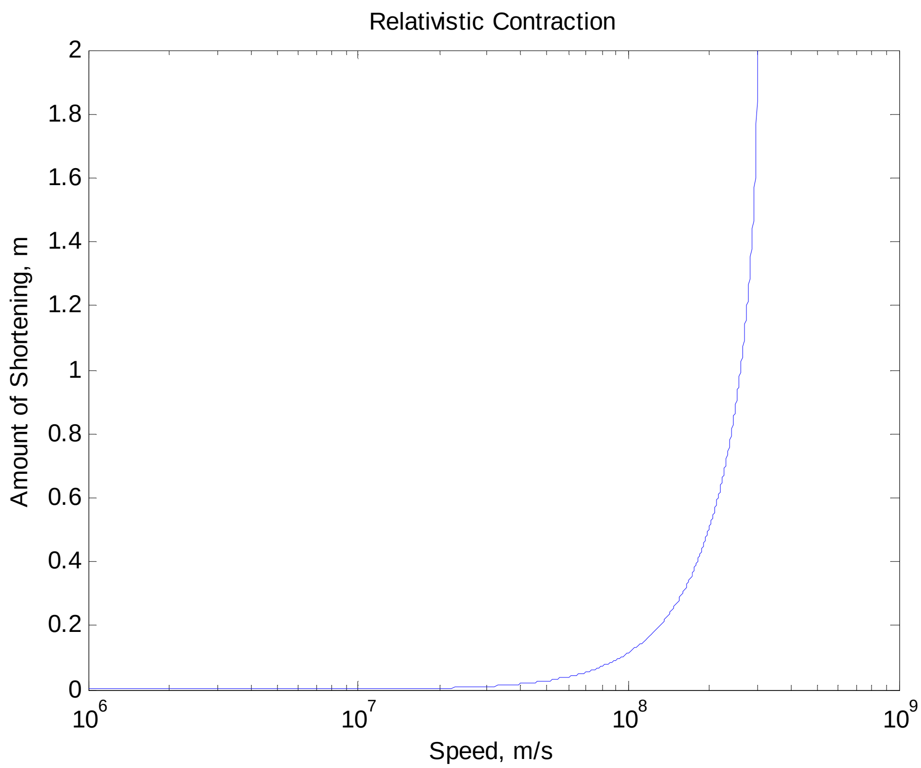
Script file:

```
L=2; c=300e6; v=0:1.e6:c;
delta=L*(1-sqrt(1-v.^2/c^2));
figure(1)
plot(v,delta)
title('Relativistic Contraction')
xlabel('Speed, m/s')
ylabel('Amount of Shortening, m')
figure(2)
semilogx(v,delta)
title('Relativistic Contraction')
xlabel('Speed, m/s')
ylabel('Amount of Shortening, m')
figure(3)
loglog(v,delta)
title('Relativistic Contraction')
xlabel('Speed, m/s')
ylabel('Amount of Shortening, m')
```

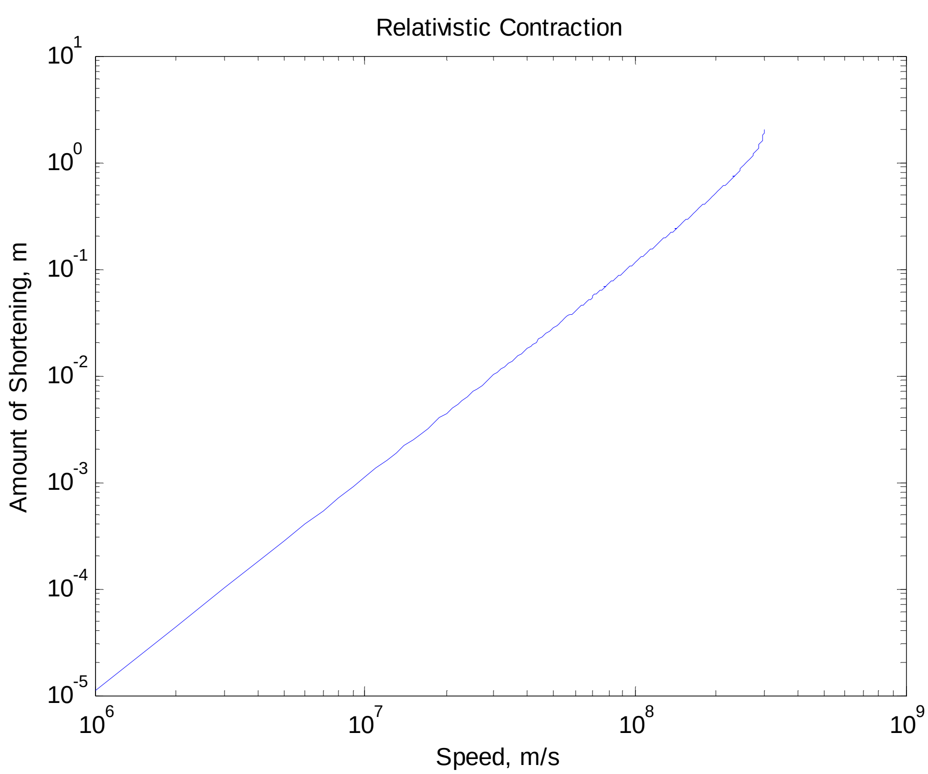
Figure Window:




```
The linear plot is useful for telling when the level of contraction becomes
significant.  The log-log plot is useful because the relationship is almost
linear when plotted this way.
```



Relativistic Contraction
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Amount of Shortening, m
10^6
10^7
10^8
10^9
Speed, m/s



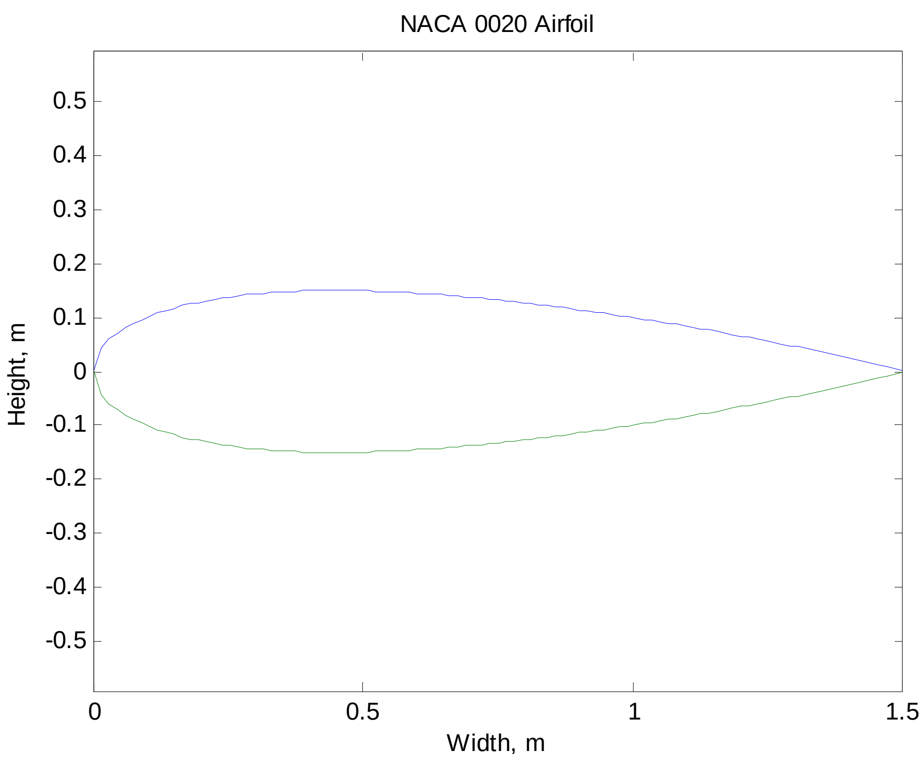
Relativistic Contraction
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
Amount of Shortening, m
10^6
10^7
10^8
10^9
Speed, m/s

Problem 30

Script file:

```
t=0.2; c=1.5; xc=0:.01:1;
y1=t*c/0.2*(0.2969*sqrt(xc)-0.1260*xc-0.3516*xc.^2+0.2843*xc.^3-
0.1015*xc.^4);
y2=-y1;
plot(xc*c,y1,xc*c,y2)
axis equal
title('NACA 0020 Airfoil')
xlabel('Width, m')
ylabel('Height, m')
```

Figure Window:

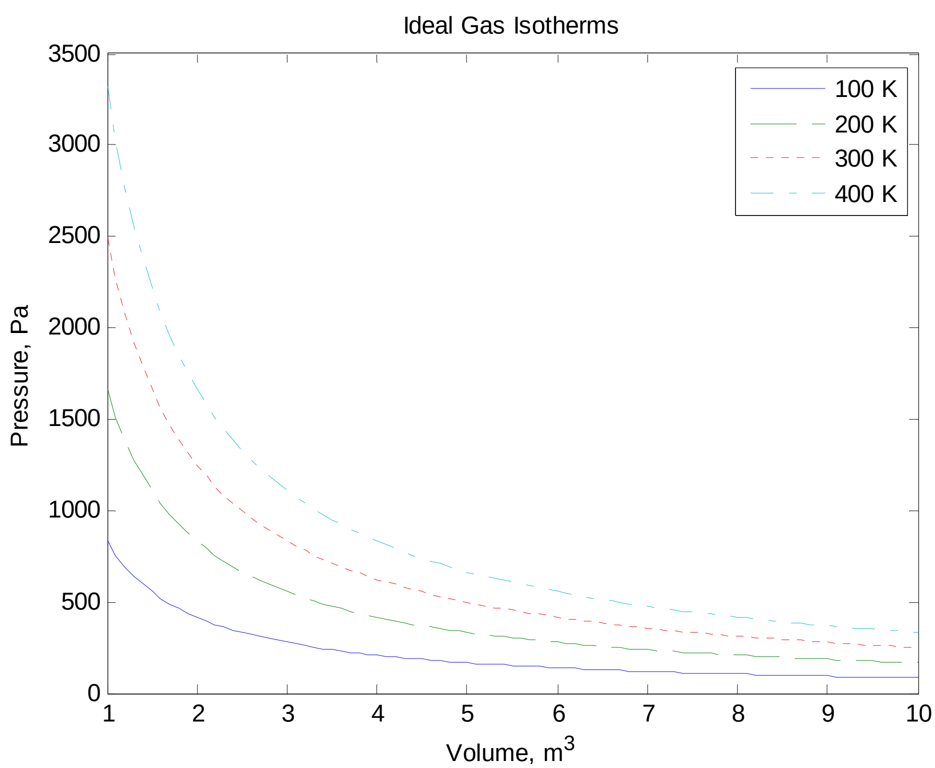


Problem 31

Script file:

```
R=8.3145;
V=1:.1:10;
P1=R*100./V; P2=R*200./V; P3=R*300./V; P4=R*400./V;
plot(V,P1,V,P2,'--',V,P3,':',V,P4,'-.')
title('Ideal Gas Isotherms')
xlabel('Volume, m^3')
ylabel('Pressure, Pa')
legend('100 K','200 K','300 K','400 K')
```

Figure Window:

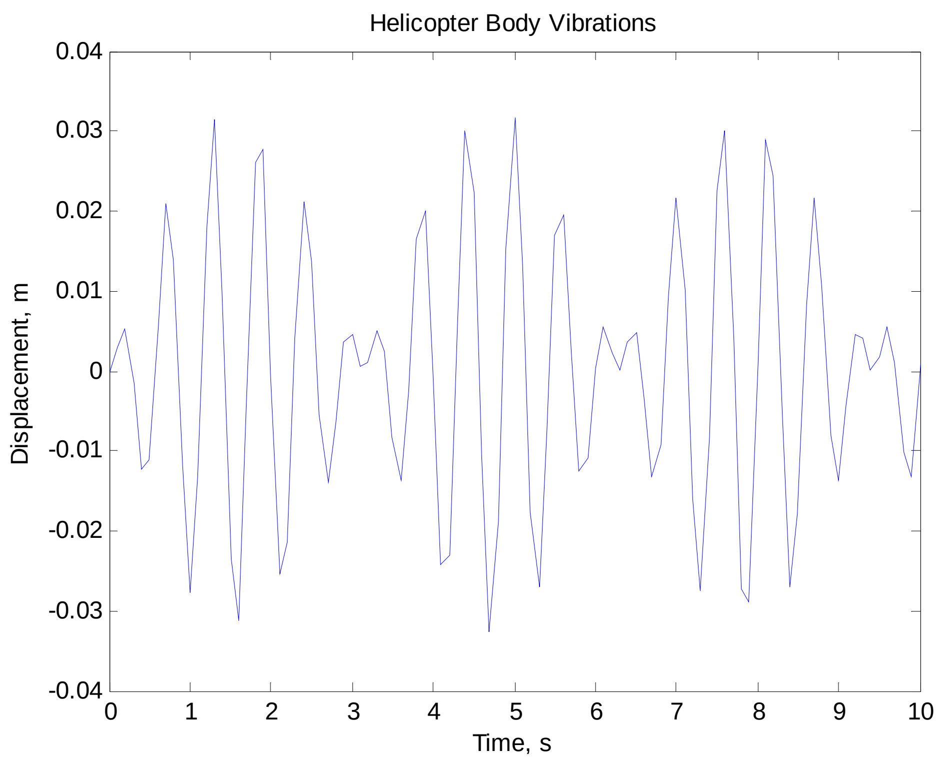


Problem 32

Script file:

```
f0=12; wn=10; w=12;
t=0:.1:10;
x=2*f0/(wn^3-w^3)*sin((wn-w)*t/2).*sin((wn+w)*t/2)
plot(t,x)
title('Helicopter Body Vibrations')
xlabel('Time, s')
ylabel('Displacement, m')
```

Figure Window:

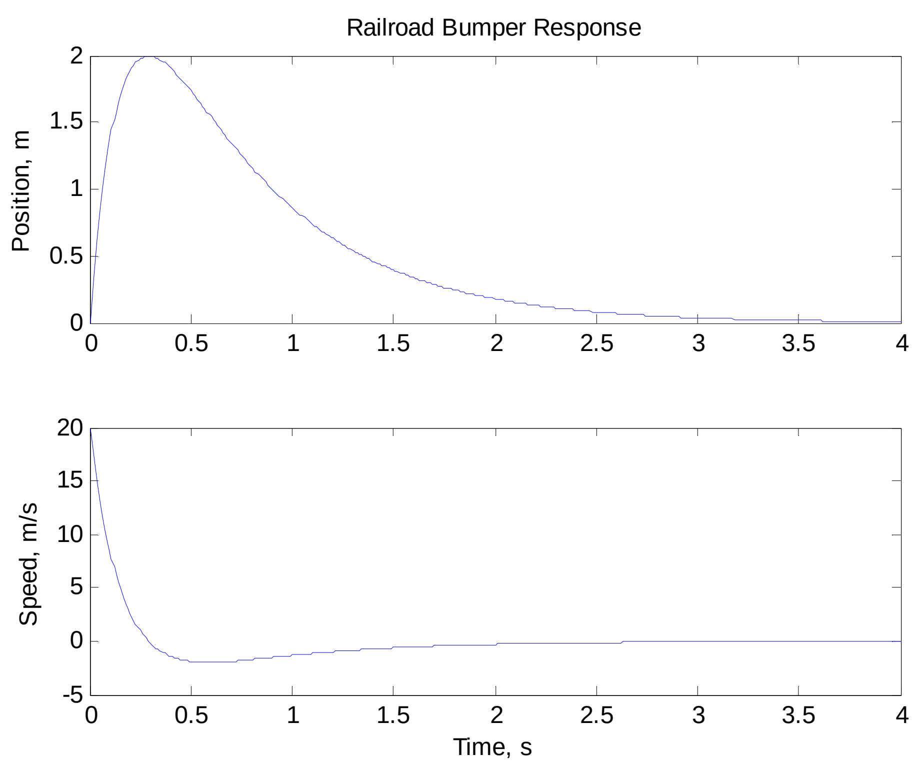


Problem 33

Script file:

```
t=0:.01:4;
x=4.219*(exp(-1.58*t)-exp(-6.32*t));
v=26.67*exp(-6.32*t)-6.67*exp(-1.58*t);
subplot(2,1,1)
plot(t,x)
title('Railroad Bumper Response')
ylabel('Position, m')
subplot(2,1,2)
plot(t,v)
ylabel('Speed, m/s')
xlabel('Time, s')
```

Figure Window:

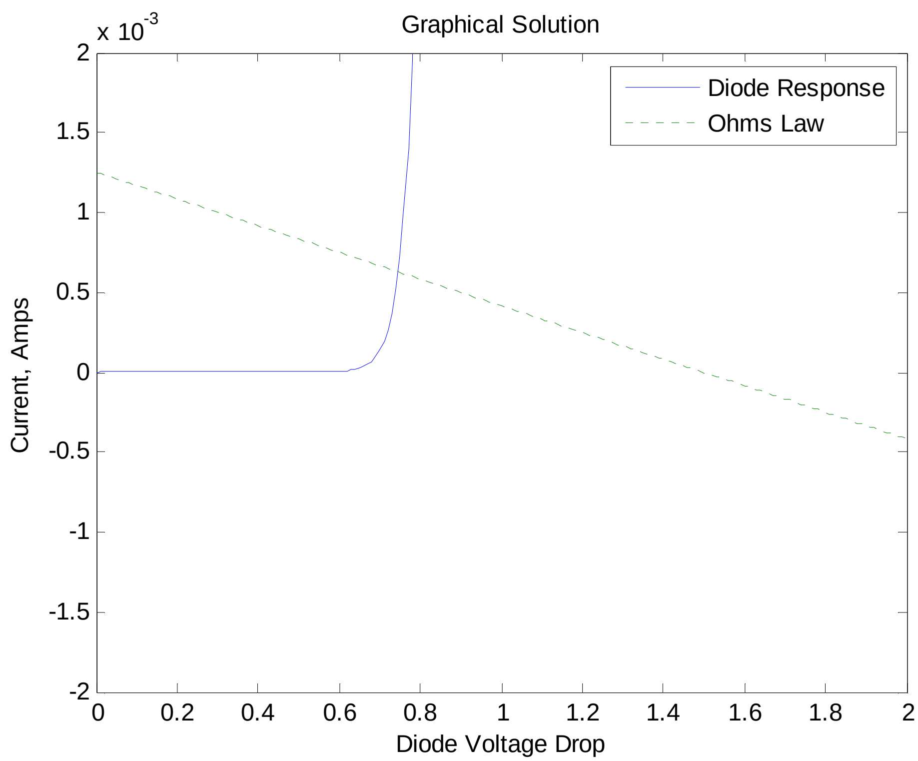


Problem 34

Script file:

```
Io=1.e-14; vs=1.5; R=1200; kt_q=.03;
vd=0:.01:2;
id1=Io*(exp(vd/kt_q)-1);
id2=(vs-vd)/R;
plot(vd,id1,vd,id2,':')
axis([0 2 -.002 .002])
title('Graphical Solution')
xlabel('Diode Voltage Drop')
ylabel('Current, Amps')
legend('Diode Response','Ohms Law')
```

Figure Window:

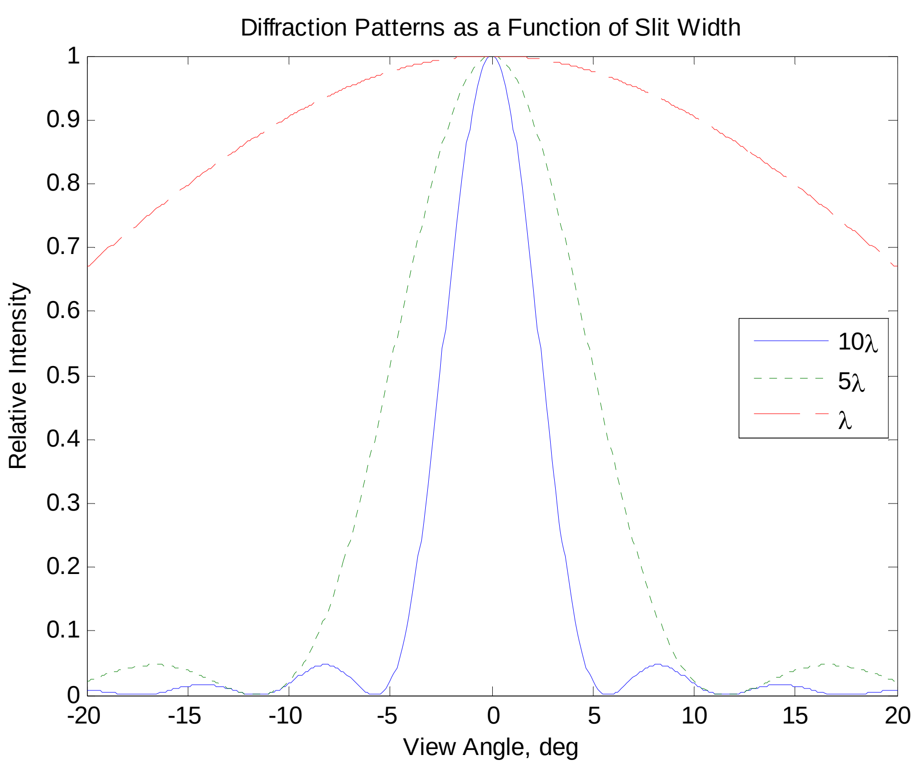


Problem 35

Script file:

```
theta=-20:.1:20;
alpha1=pi*10*sind(theta);
alpha2=pi*5*sind(theta);
alpha3=pi*sind(theta);
Iratio1=(sin(alpha1)./alpha1).^2;
Iratio2=(sin(alpha2)./alpha2).^2;
Iratio3=(sin(alpha3)./alpha3).^2;
plot(theta,Iratio1,theta,Iratio2,':',theta,Iratio3,'--')
title('Diffraction Patterns as a Function of Slit Width')
xlabel('View Angle, deg')
ylabel('Relative Intensity')
legend('10\lambda','5\lambda','\lambda','location','East')
```

Figure Window:

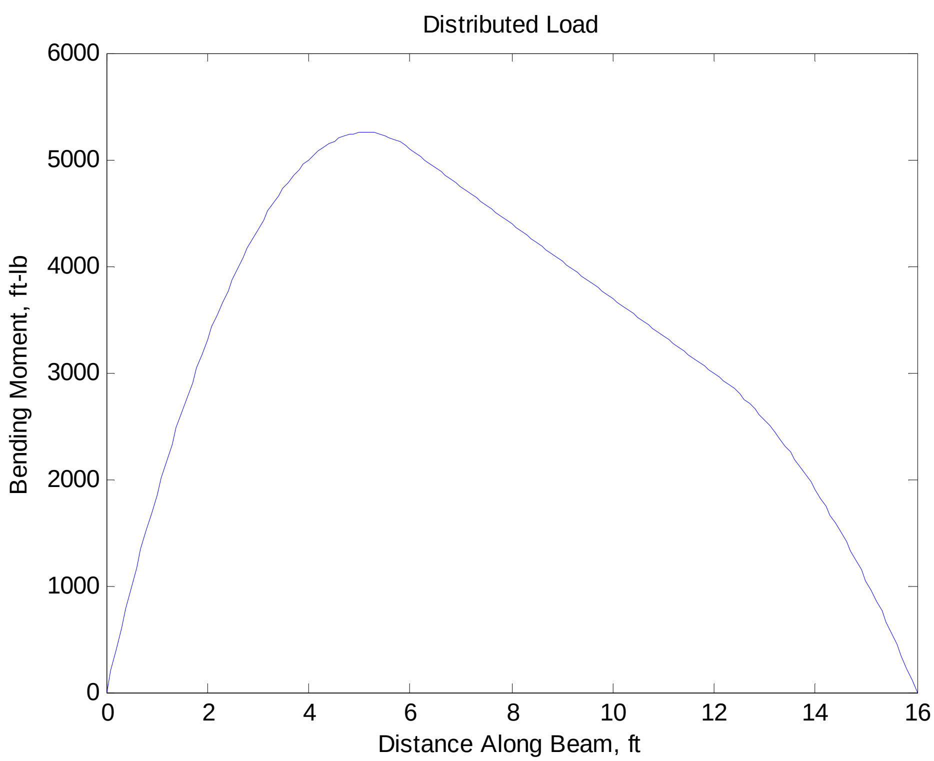


Problem 36

Script file:

```
L=16; a=6; b=6; c=L-a-b; w1=400; w2=200;
RA=(w1*a*(2*L-a)+w2*c^2)/(2*L);
RB=(w2*c*(2*L-c)+w1*a^2)/(2*L);
x1=0:.1:a; x2=a:.1:(a+b); x3=(a+b):.1:L;
M1=RA*x1-w1*x1.^2/2;
M2=RA*x2-w1*a.*(2*x2-a)/2;
M3=RB*(L-x3)-w2*(L-x3).^2/2;
x=[x1 x2 x3]; M=[M1 M2 M3];
plot(x,M)
title('Distributed Load')
xlabel('Distance Along Beam, ft')
ylabel('Bending Moment, ft-lb')
```

Figure Window:

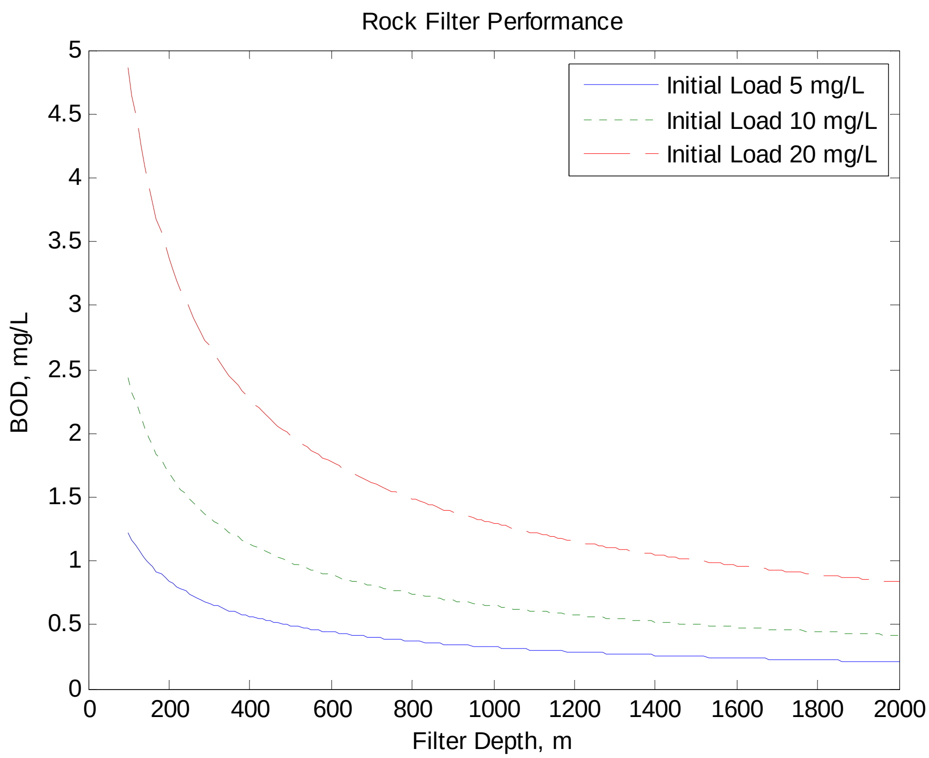


Problem 37

Script file:

```
Q=300; D=100:10:2000; L1=5; L2=10; L3=20;
Lc1=L1./(1+2.5*D.^(2/3)/sqrt(Q));
Lc2=L2./(1+2.5*D.^(2/3)/sqrt(Q));
Lc3=L3./(1+2.5*D.^(2/3)/sqrt(Q));
plot(D,Lc1,D,Lc2,':',D,Lc3,'--')
title('Rock Filter Performance')
xlabel('Filter Depth, m')
ylabel('BOD, mg/L')
legend('Initial Load 5 mg/L','Initial Load 10 mg/L','Initial Load 20 mg/L')
```

Figure Window:

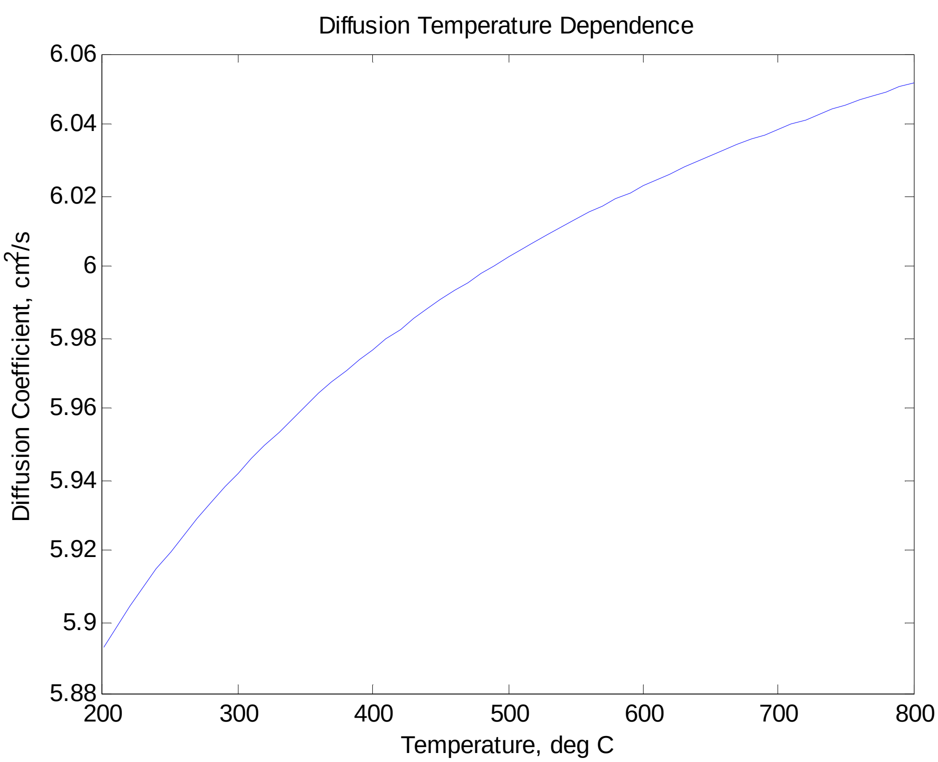


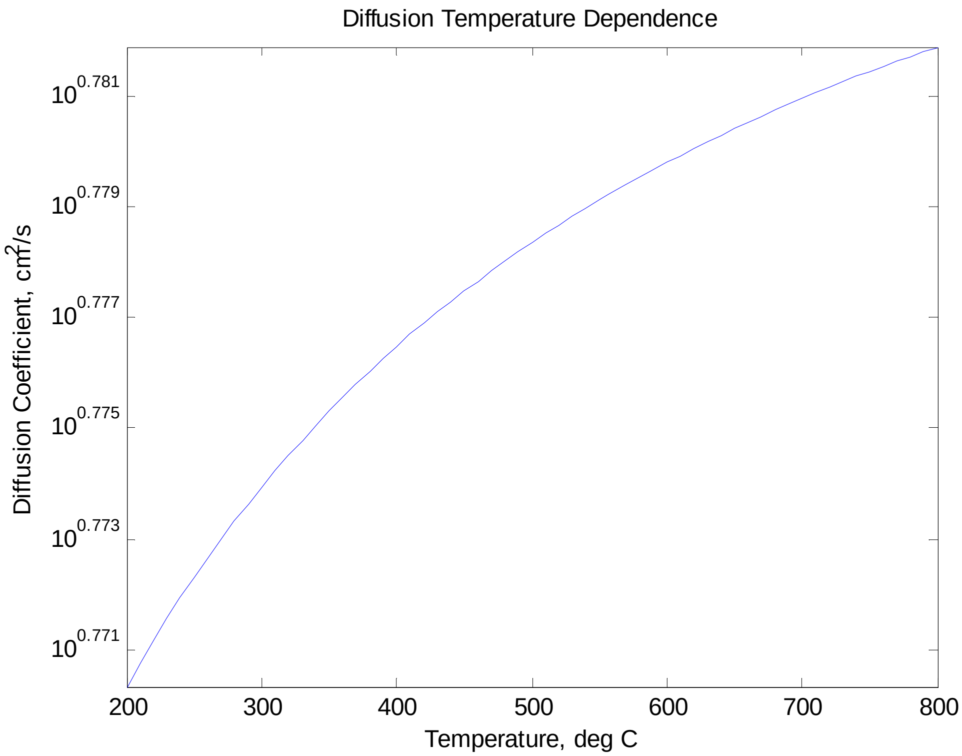
Problem 38

Script file:

```
R=8.31; D0=6.18; Ea=187;
Tc=200:10:800;
T=Tc+273.15;
D=D0*exp(-Ea./(R*T));
figure(1)
plot(Tc,D)
title('Diffusion Temperature Dependence')
xlabel('Temperature, deg C')
ylabel('Diffusion Coefficient, cm^2/s')
figure(2)
semilogy(Tc,D)
title('Diffusion Temperature Dependence')
xlabel('Temperature, deg C')
ylabel('Diffusion Coefficient, cm^2/s')
```

Figure Window:





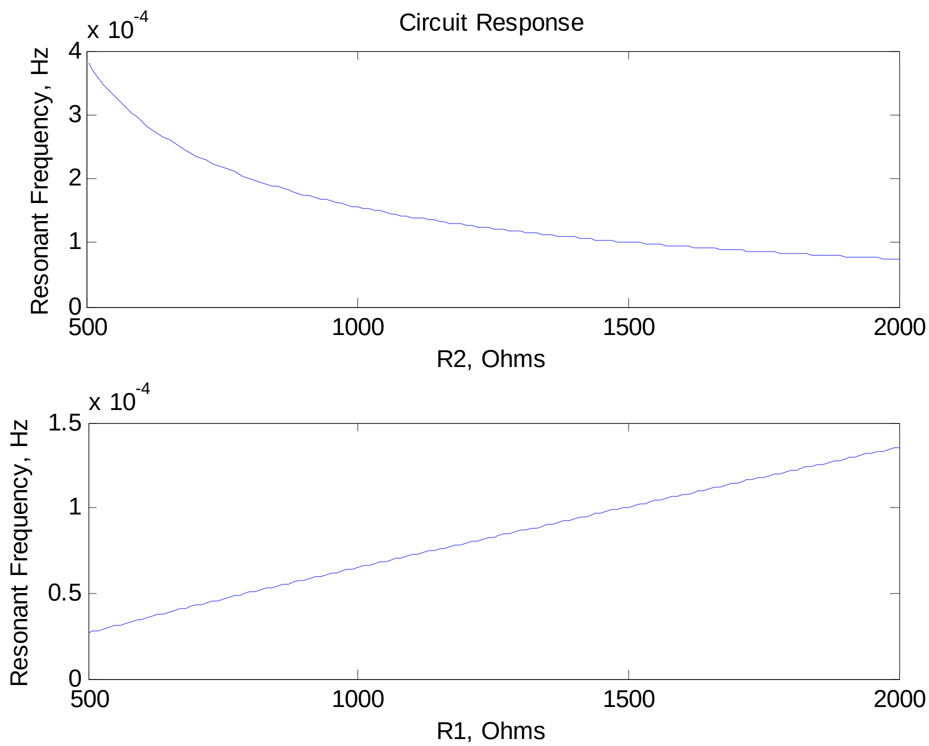
The range of values of D is small, so the linear plot is more useful.

Problem 39

Script file:

```
L=0.2; C=2e-6;
R1=1500; R2=500:10:2000;
f=sqrt(L*C*(R1^2*C-L)./(R2.^2*C-L))/(2*pi);
subplot(2,1,1)
plot(R2,f)
title('Circuit Response')
ylabel('Resonant Frequency, Hz')
xlabel('R2, Ohms')
R2=1500; R1=500:10:2000;
f=sqrt(L*C*(R1.^2*C-L)/(R2^2*C-L))/(2*pi);
subplot(2,1,2)
plot(R1,f)
ylabel('Resonant Frequency, Hz')
xlabel('R1, Ohms')
```

Figure Window:



Problem 40

Script file:

```
x=linspace(-2*pi,2*pi,200);
p1=cos(x);
p2=1-x.^2/2;
p3=p2+x.^4/24-x.^6/factorial(6);
p4=p3+x.^8/factorial(8) - x.^10/factorial(10);
plot(x,p1,x,p2,'-.',x,p3,':',x,p4,'--')
axis([-8 8 -2 2])
title('Taylor Series Approximation')
xlabel('Angle, rad')
ylabel('Magnitude')
```

Figure Window: