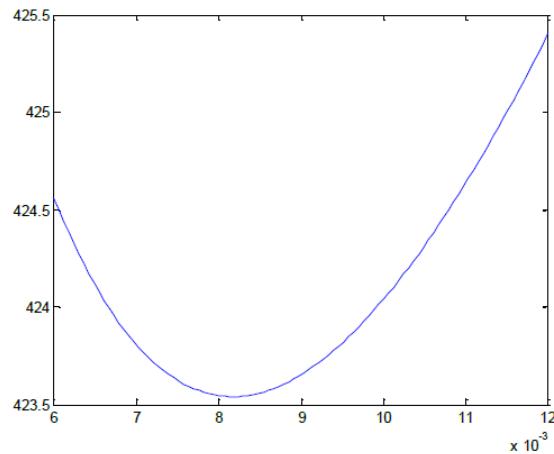


7.16 The following script generates a plot of wire temperature versus insulation thickness. Then, it employs `fminbnd` to locate the thickness of insulation that minimizes the wire's temperature.

```
clear,clc,clf,format short g
q=75;rw=6e-3;k=0.17;h=12;Tair=293;
rplot=linspace(rw,rw*2);
T=@(ri) Tair+q/(2*pi)*(1/k*log((rw+ri)/rw)+1/h*1./(rw+ri));
Tplot=T(rplot);
plot(rplot,Tplot)
[rimin Tmin]=fminbnd(T,rw,2*rw)
rtotal=rimin+rw
```



```
rimin =
    0.0081725
Tmin =
    423.54
rtotal =
    0.014173
```

Thus, an insulation thickness of 8.1725 mm yields a minimum wire temperature of 423.54 K. The total radius of the wire and insulation is 14.1725 mm.

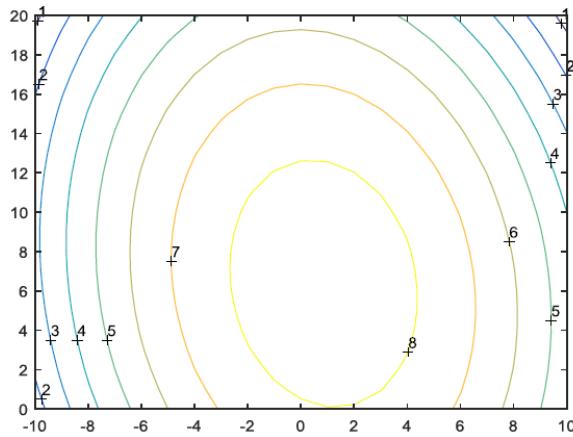
7.28 This problem can be solved in a number of different ways. For example, using the golden section search, the result is

i	c_l	$g(c_l)$	c_u	$g(c_u)$	c_l	$g(c_l)$	c_u	$g(c_u)$	d	c_{opt}	ϵ_a
1	0.0000	0.0000	3.8197	0.2330	6.1803	0.1310	10.0000	0.0641	6.1803	3.8197	100.00%
2	0.0000	0.0000	2.3607	0.3350	3.8197	0.2330	6.1803	0.1310	3.8197	2.3607	100.00%
3	0.0000	0.0000	1.4590	0.3686	2.3607	0.3350	3.8197	0.2330	2.3607	1.4590	100.00%
4	0.0000	0.0000	0.9017	0.3174	1.4590	0.3686	2.3607	0.3350	1.4590	1.4590	61.80%
5	0.9017	0.3174	1.4590	0.3686	1.8034	0.3655	2.3607	0.3350	0.9017	1.4590	38.20%
6	0.9017	0.3174	1.2461	0.3593	1.4590	0.3686	1.8034	0.3655	0.5573	1.4590	23.61%
7	1.2461	0.3593	1.4590	0.3686	1.5905	0.3696	1.8034	0.3655	0.3444	1.5905	13.38%
8	1.4590	0.3686	1.5905	0.3696	1.6718	0.3688	1.8034	0.3655	0.2129	1.5905	8.27%
9	1.4590	0.3686	1.5403	0.3696	1.5905	0.3696	1.6718	0.3688	0.1316	1.5905	5.11%
10	1.5403	0.3696	1.5905	0.3696	1.6216	0.3694	1.6718	0.3688	0.0813	1.5905	3.16%
11	1.5403	0.3696	1.5713	0.3696	1.5905	0.3696	1.6216	0.3694	0.0502	1.5713	1.98%
12	1.5403	0.3696	1.5595	0.3696	1.5713	0.3696	1.5905	0.3696	0.0311	1.5713	1.22%
13	1.5595	0.3696	1.5713	0.3696	1.5787	0.3696	1.5905	0.3696	0.0192	1.5713	0.75%

Thus, after 13 iterations, the method is converging on the true value of $c = 1.5679$ which corresponds to a maximum specific growth rate of $g = 0.36963$.

7.32 This problem can be solved graphically by using MATLAB to generate a contour plot of the function. As can be seen, a minimum occurs at approximately $x = 1$ and $y = -7$.

```
clear,clc,format long,format compact
[x,y]=meshgrid(-10:10,0:20);
c=7.9+0.13*x+0.21*y-0.05*x.^2-0.016*y.^2-0.007*x.*y;
cs=contour(x,y,c);clabel(cs)
```



We can use MATLAB to determine a maximum of 8.6249 at $x = 0.853689$ and $y = 6.375787$.

```

c=@(x) -(7.9+0.13*x(1)+0.21*x(2)-0.05*x(1).^2 ...
-0.016*x(2).^2-0.007*x(1).*x(2));
[x,fval]= fminsearch(c,[0,0])
x =
    0.853689449708418    6.375787481090514
fval =
   -8.624944462056112

```

7.33 The solution can be developed as a MATLAB script yielding $F = 1.709$ at $x = 0.6364$,

```

clear, clc, format long
e0=8.85e-12;q=2e-5;Q=q;a=0.9;
F=@(x) -(1/(4*pi*e0)*q*Q*x/(x^2+a^2)^(3/2));
[x,Fx]=fminsearch(F,0.5)

x =
    0.63642578125000
Fx =
   -1.70910974594861

```

7.44 If $t = 0$ is defined as the time at which each water droplet leaves the nozzle, the x and y coordinates can be computed as a function of time with

$$x = L \cos \theta + v_0 \cos \theta t$$

$$y = h_l + L \sin \theta + v_0 \sin \theta t - 0.5gt^2$$

By setting $y = h_2$, the second equation becomes

$$0.5gt^2 - v_0 \sin \theta t + h_2 - h_l - L \sin \theta = 0$$

which can be solved with the quadratic formula as

$$\frac{t_2}{t_1} = \frac{v_0 \sin \theta \pm \sqrt{v_0^2 \sin^2 \theta - 2g(h_2 - h_l - L \sin \theta)}}{g}$$

where t_1 = the time at which the stream just clears the front of the roof (s), and t_2 = the time at which the stream lands on the surface (s). For the x equation, we can set $t = t_1$ and solve for

$$x_1 = L \cos \theta + v_0 \cos \theta t_1$$

The distance to the point where the stream hits the roof can then be determined by substituting $t = t_2$,

$$x_2 = L \cos \theta + v_0 \cos \theta t_2$$

Therefore, the length of roof that can be watered is

$$f(\theta) = x_2 - x_1 = v_0 \cos \theta (t_2 - t_1)$$

MATLAB can then be used to determine the value of θ that maximizes this function. Here is one way to do that:

```
clear, clc, format long, format compact
h1=0.06;h2=0.2;L=0.12;
v0=3;g=9.81;
angle=fminbnd(@f,35,70,[],v0,g,h1,h2,L)
[x1,x2]=fth(angle,v0,g,h1,h2,L)
xwetted=x2-x1

function [dx] = f(theta,v0,g,h1,h2,L)
[x1,x2]=fth(theta,v0,g,h1,h2,L);
dx=x1-x2;
end

function [x1,x2] = fth(theta,v0,g,h1,h2,L)
theta=theta*pi/180;
disc=v0^2*sin(theta)^2-2*g*(h2-h1-L*sin(theta));
t1=(v0*sin(theta)-sqrt(disc))/g;
t2=(v0*sin(theta)+sqrt(disc))/g;
x1=L*cos(theta)+v0*cos(theta)*t1;
x2=L*cos(theta)+v0*cos(theta)*t2;
end
```

When the script is run, the result is

```
angle =
 50.041278607482660
x1 =
 0.119274300628795
x2 =
 0.938125095072800
xwetted =
 0.818850794444005
```