Introduction :

In this lab, we seek to determine if the relationship $\Delta(V_{terminal}) = \Delta(V_{capacitor}) + \Delta(V_{resistor})$ holds when a capacitor is charged through a resistor. In combining this relation with the equation for charging a capacitor, we get the equation $\Delta(V_{Resistor}) = \Delta(V_{Terminal})\,\mathbf{e}^{\left(-\frac{t}{\tau}\right)}$. We can then transform this relation into $\ln(\Delta(V_{Resistor})) = \left(-\frac{1}{\tau}\right)t + \ln(\Delta(V_{Terminal}))$. We can then replace $\ln(\Delta(V_{Resistor}))$ with Y and $\ln(\Delta(V_{Terminal}))$ with B to make the linear relation $Y = \left(-\frac{1}{\tau}\right)t + B$. This line has a predicted slope of $-\frac{1}{\tau}$ and an intercept of B. After plotting this graph, we can compare the calculated terminal voltage and the calculated τ with the values measured in the lab.

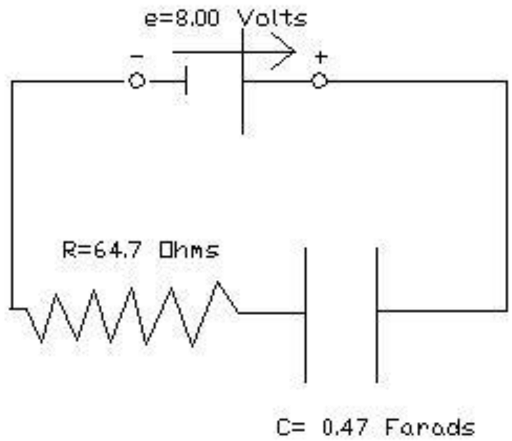
Equipment :

See the John Abbott College Physics NYB Lab Manual for the winter 2000 semester for a complete equipment list

Procedures :

See the John Abbott College Physics NYB Lab Manual for the winter 2000 semester for full procedures.

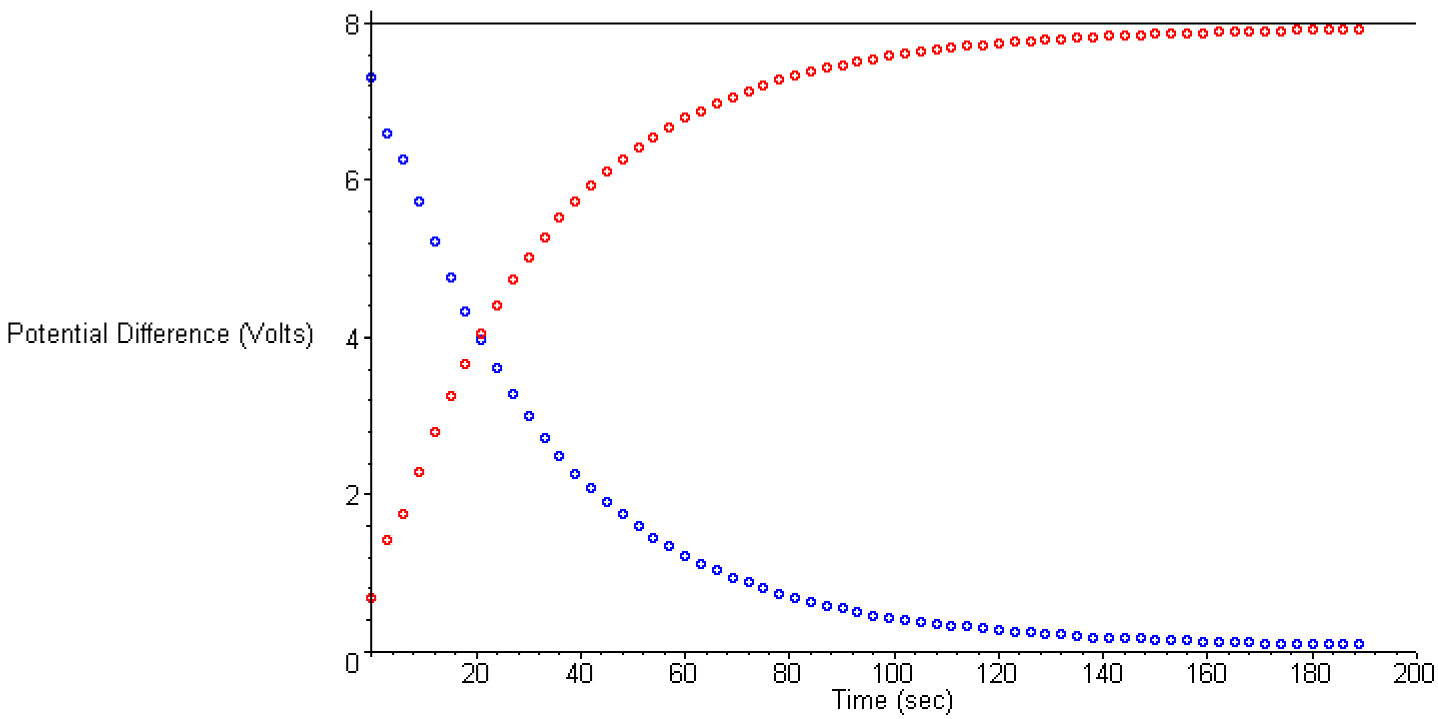
Diagram:



Data :

Complete data available upon request E-mail me at j_con999@yahoo.com

Comparing the potential difference spanning the Terminal,Resistance & Capacitor



Calculations

```
for i from 1 to 3 do

readline("a:/capac3.txt")

od;
```

"Ch A\tCh B\tCh C"

"Run #1\tRun #1\tRun #1"

"Voltage (V)\tVoltage (V)\tVoltage (V)"

```
R1:=readdata("a:/capac3.txt",3):nops(%);
```

64

```
v1:=[seq(R1[i,1],i=1..nops(R1))]:

Voltage[t]:=add(v1[i],i=1..nops(v1))/nops(v1);
```

$$Voltage_t := 8.003$$

```
d:=describe[meandeviation](v1);
```

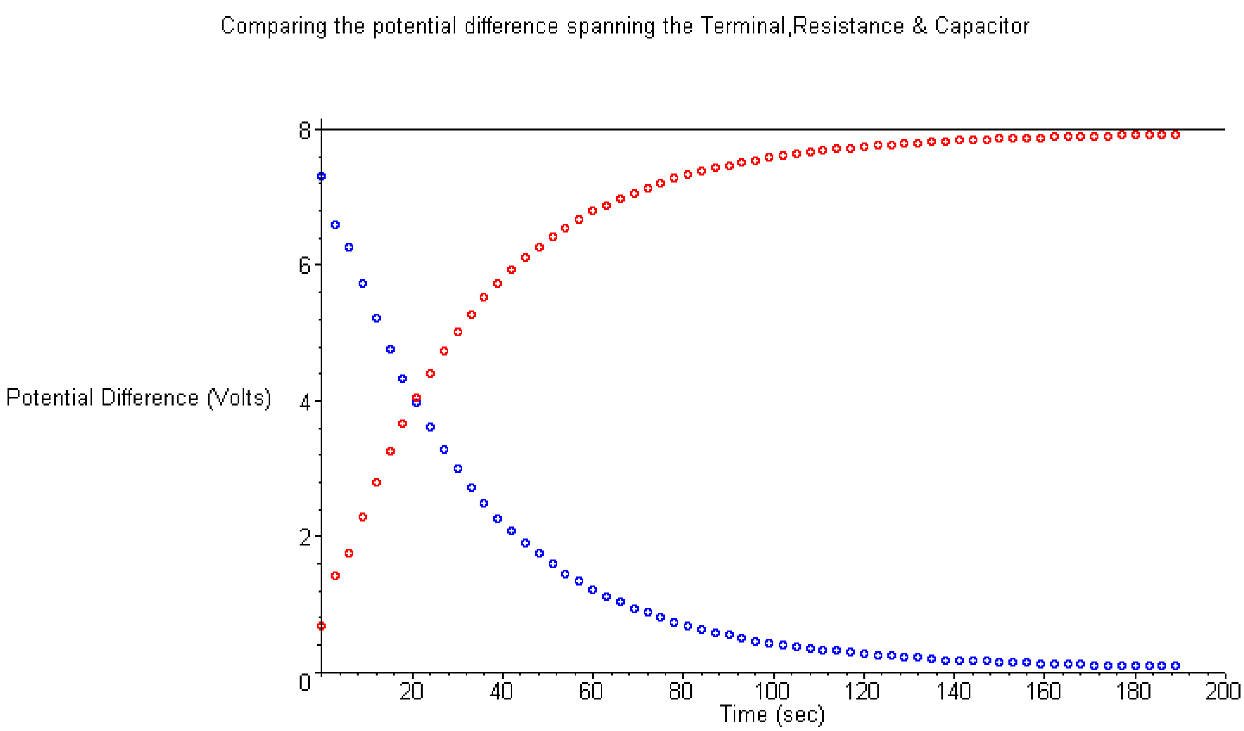
$$d := .01334$$

```
`% deviation`:=d/Voltage[t]*100;
```

$$\%\ deviation := .1667$$

```
vc:=[seq((R1[i,3]),i=1..nops(R1))]:

vr:=[seq((R1[i,2]),i=1..nops(R1))]:

Datac:=[seq([`ti`[i],vc[i]],i=1..64)]:

Datar:=[seq([`ti`[i],vr[i]],i=1..64)]:
```

```
A:=plot(Datac,style=point,symbol=circle,color=red,title="Comparing the potential difference spanning the Terminal,Resistance & Capacitor",labels=[`Time (sec)`,`Potential Difference (Volts)`]):

B:=plot(Datar,style=point,symbol=circle,color=blue):

C:=plot(Voltage[t],x=0..200,color=black):

display([A,B,C]);
```




```
Y:=[seq(ln(vr[i]),i=1..64)]:

Ydata:=[seq([`ti`[i],Y[i]],i=1..64)]:

A:=plot(Ydata[1..35],style=point,symbol=circle,color=black):

eq:=fit[leastsquare[[x,y],y=a*x+b,{a,b}]]([`ti`[1..45],Y[1..45]]);
```

$$eq := y = -.02742\,x + 1.912$$

```
Fr:=unapply(rhs(%),x);
```

$$Fr := x \to -.02742\,x + 1.912$$

B:=plot(Fr(x),x=0..100):

C:=textplot([75,1.5,`Middle=Best  Line`], colour=red, align=ABOVE):G:=textplot([21,1.8,`Max Line`], colour=blue, align=ABOVE):H:=textplot([10,1,`Min Line`], colour=green, align=ABOVE):

J:=[132.08,58.56]:K:=[-1.51,.24]:L:=[86.45,6.34]:M:=[-.61,1.91]:

EqMin:=fit[leastsquare[[x,y],y=a*x+b,{a,b}]]([J,K]);

$$EqMin := y = -.02379\, x + 1.633$$

Fmin:=unapply(rhs(%),x);

$$Fmin := x \to -.02379\, x + 1.633$$

Pmin:=plot(Fmin(x),x=0..100,color=green):

EqMax:=fit[leastsquare[[x,y],y=a*x+b,{a,b}]]([L,M]);

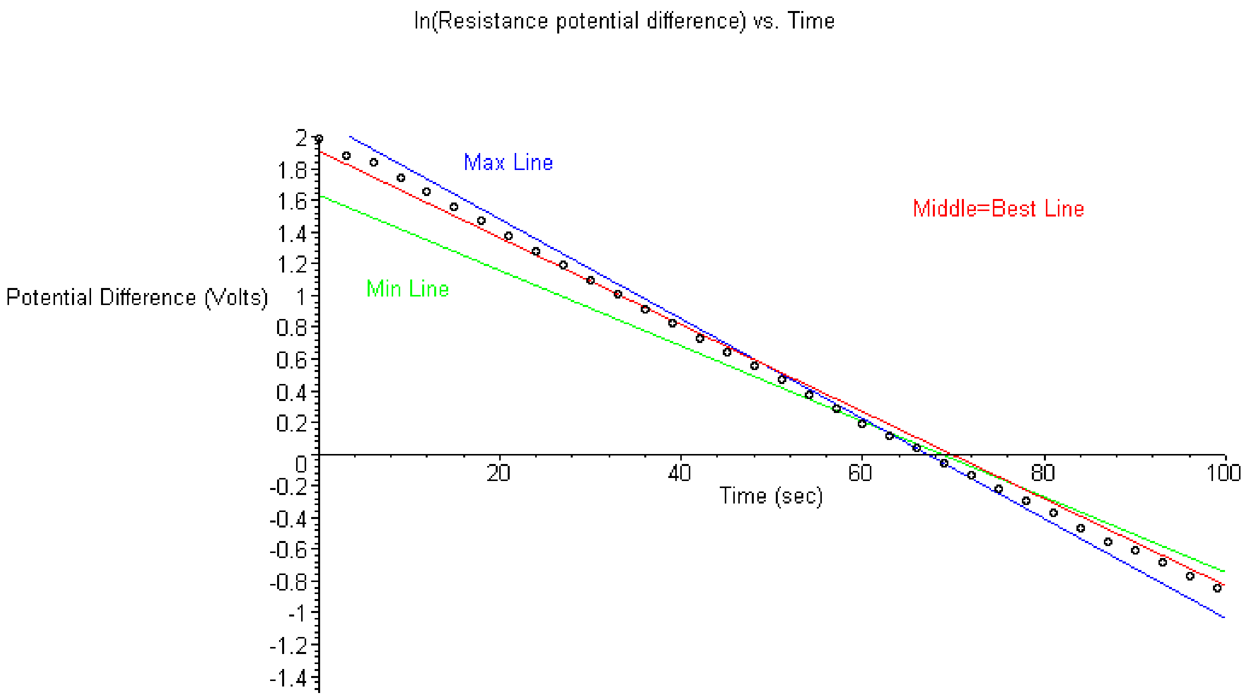
$$EqMax := y = -.03146\, x + 2.110$$

Fmax:=unapply(rhs(%),x);

$$Fmax := x \to -.03146\, x + 2.110$$

Pmax:=plot(Fmax(x),x=0..100,y=-1.5..2,color=blue):

display([A,B,C,G,H,Pmax,Pmin],title="ln(Resistance potential difference) vs. Time",labels=[`Time (sec)`,`Potential Difference (Volts)`]);



`Data slope`:=-.2742e-1;

`min slope`:=-.2379e-1;

`max slope`:=-.3146e-1;

uncertainty:=abs((`min slope`+`max slope`)/2-`Data slope`);

`% uncertanty`:=abs(uncertainty/`Data slope`)*100;

$$\mathit{Data\ slope} := -.02742$$

$$\mathit{min\ slope} := -.02379$$

$$\mathit{max\ slope} := -.03146$$

$$\mathit{uncertainty} := .00021$$

$$\%\ \mathit{uncertanty} := .7659$$

`Data intersept`:=1.912;

`min intersept`:=1.633;

`max intersept`:=2.110;

uncertaintyi:=abs((`min intersept`+`max intersept`)/2-`Data intersept`);

$$Data\ intersept := 1.912$$

$$min\ intersept := 1.633$$

$$max\ intersept := 2.110$$

$$uncertaintyi := .040$$

Percentage Difference Calculations

R:=64.7;

C:=.47;

tau:=(R*C);

taud:=-1/`Data slope`;

`uncertanty of tau`:=abs((1/(`min slope`)+1/(`max slope`))/2);

`% uncertanty of tau`:=abs(`uncertanty of tau`/tau*100);

`% difference of tau`:=(taud-tau)/(taud+tau)*200;

$$R := 64.7$$

$$C := .47$$

$$\tau := 30.41$$

$$taud := 36.47$$

$$uncertanty\ of\ tau := 36.92$$

$$\%\ uncertanty\ of\ tau := 121.4$$

$$\%\ difference\ of\ tau := 18.12$$

`Terminal Voltage from graph`:=exp(`Data intersept`);

`uncertanty of V[t]`:=exp(uncertaintyi);

`% difference of Terminal Voltage`:=abs((`Terminal Voltage from graph`-Voltage[t])/(`Terminal Voltage from graph`+Voltage[t])*200);

$$Terminal\ Voltage\ from\ graph := 6.767$$

$$uncertanty\ of\ V[t] := 1.041$$

$$\%\ difference\ of\ Terminal\ Voltage := 16.74$$

Results

	Measured	From Graph	% Difference
Tau	36.47	36.47±121%	18%
Terminal Voltage	8.00±.013	6.77±1.04	17%

Conclusion :

In this lab, we have proven that, within experimental uncertanty, the relation $\Delta(V_{Terminal}) = \Delta(V_{Capacitor}) + \Delta(V_{Resistor})$ does apply to a capacitor and a resistor when they are mounted in series. We did discover a linear relation with a slope and intercept comparable to our predicted values. While the percent differences between the measured and calculated values were reasonable in size, they were easily encompassed by the uncertainty of the calculated values.

The source of this uncertainty stems from slight variances in the terminal voltage of the power supply. As this value fluctuates, the rate of charging on the capacitor changes, this in turn alters the differential equation used to create our linear graph. The change in temperature in the resistance and the migration of electrons across the space separating the parallel plates of the capacitor are also not accounted for in our equations.