Fitting of motor parameters to finite element inductance results.

This information was obtained via finite element analysis. The first column is frequency in Hz, the second is the real part of the inductance of one phase, and the third column is the imaginary part of the inductance of one phase.

```
In[10]:= a = {
  {0.25`, 3.113896850223534`, -0.7856218453620856`},
  {0.5`, 2.644535219245725`, -1.302070241302897`},
  {0.75`, 2.126343173595966`, -1.537900872595692`},
  {1, 1.68320257396424`, -1.583616667778593`},
  {1.25`, 1.342042927068295`, -1.532303361240956`},
  {1.5`, 1.088911996246064`, -1.441388199690263`},
  {1.75`, 0.9020968041951417`, -1.339803795461847`},
  {2, 0.7630198291077501`, -1.240517339450469`},
  {2.25`, 0.6579818291161289`, -1.148644116425449`},
  {2.5`, 0.5773601434853864`, -1.065680060490867`},
  {2.75`, 0.5144745255439016`, -0.9915441223769652`},
  {3, 0.464668655223232`, -0.9255306693744174`}
};
```

```
In[11]:= a = Transpose[a];
```

Scale frequency so that it is in units of rad/sec. For convenience, denote the columns of data w, Lr and Li

```
In[14]:= w = 2 Pi a[[1]];
         Lr = a[[2]];
         Li = a[[3]];
```

Build matrices necessary for the first problem to get tau and M:

```
A = Transpose[{w, w * w * Li}]

Out[17]= {{1.5708, -1.93844}, {3.14159, -12.8509}, {4.71239, -34.1516}, {2 π, -62.5187},
          {7.85398, -94.5202}, {9.42478, -128.033}, {10.9956, -161.986}, {4 π, -195.895},
          {14.1372, -229.567}, {15.708, -262.946}, {17.2788, -296.031}, {6 π, -328.846}}
```

```
In[18]:= b = -Li

Out[18]= {0.785622, 1.30207, 1.5379, 1.58362, 1.5323,
          1.44139, 1.3398, 1.24052, 1.14864, 1.06568, 0.991544, 0.925531}
```

Solve least-squares problem

```
In[19]:= ans = Inverse[Transpose[A].A].Transpose[A].b

Out[19]= {0.522906, 0.0271847}
```

and infer values of tau and M from the results

```
In[20]:= tau = Sqrt[ans[[2]]]

Out[20]= 0.164878
```

```
In[44]:= M = ans[[1]] / tau
```

```
Out[44]= 3.17148
```

Plot the fit versus the "data"

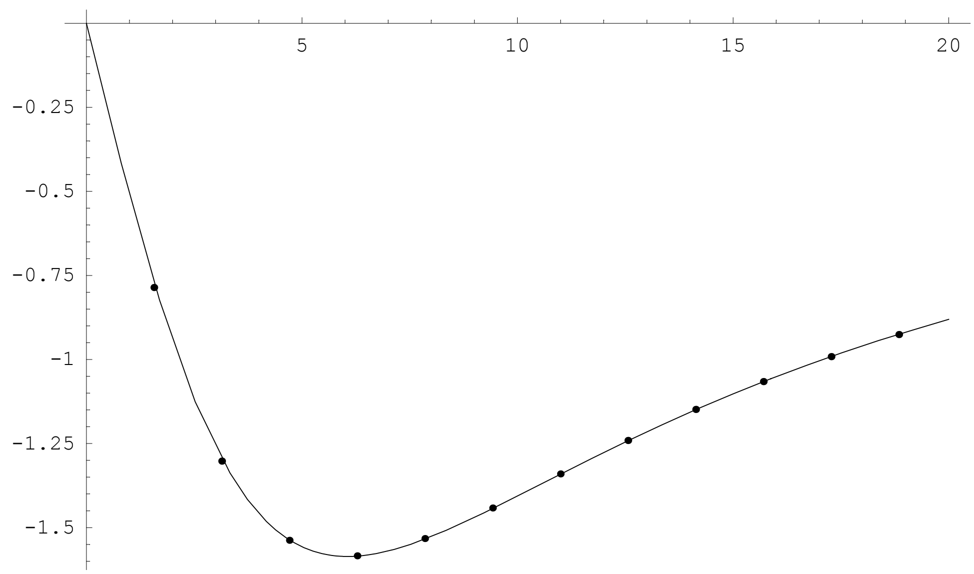
```
In[45]:= FitLi = -tau ws M / (1 + (tau ws) ^2)
```

$$\text{Out[45]= } -\frac{0.522906\,\text{ws}}{1+0.0271847\,\text{ws}^2}$$

```
In[61]:= dataplot1 = ListPlot[Transpose[{w, Li}], DisplayFunction → Identity];

In[62]:= fitplot1 = Plot[FitLi, {ws, 0, 20}, DisplayFunction → Identity];

In[63]:= Show[dataplot1, fitplot1, DisplayFunction → $DisplayFunction]
```




```
Out[63]= - Graphics -
```

Now, get the leakage from the real part of the inductance.

```
In[48]:= Lr - M / (1 + (tau w) ^2)

Out[48]= {0.141775, 0.143965, 0.148717, 0.153458, 0.15728, 0.160145,
          0.162255, 0.163817, 0.164989, 0.165883, 0.166577, 0.167125}

In[49]:= Ll = %.Table[1, {Length[%]}] / Length[%]

Out[49]= 0.157999
```

Alternatively, we could have set up a nonlinear least-squares problem that solves for all the parameters in one fell swoop. We can minimize the error directly using a "canned" minimization algorithm using the points that we had already determined as starting points for the algorithm.

```
In[56]:= eqs = Join[-t w m / (1 + (t w) ^2) - Li, ll + m / (1 + (t w) ^2) - Lr];
```

```
In[58]:= err = eqs.eqs;

In[64]:= FindMinimum[err, {m, M}, {t, tau}, {ll, Ll}]

Out[64]= {0.000971267, {m → 3.16428, t → 0.165258, ll → 0.162968}}
```