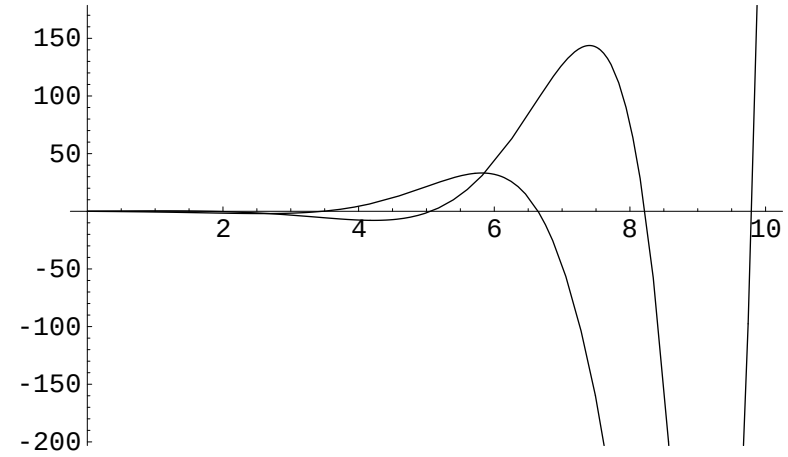
Eddy currents in spherical metal samples

■ Plot Bessel function of first kind and first order

```
Plot[{Re[BesselJ[1, x * (-1 + I)]], Im[BesselJ[1, x * (-1 + I)]]}, {x, 0, 10}]
```




```
-Graphics-
```

■ Define phi−component of magnetic vector potential A (T. Morisue, M. Fukumi, "3−D Eddy Current Calculation Using the Magnetic Vector Potential." IEEE Trans. Magn., vol. 24, no. 1, 1988)

```
mu0 = N[4 * Pi * 10^-7]
```

```
1.25664 10^-6
```

```
aphi[r_, rs_, theta_, omega_, mu_, sigma_] :=
 a[rs, kx = k[omega, mu, sigma], mu] * BesselJ[1, kx * r] * Sin[theta]

k[omega_, mu_, sigma_] := (-1 + I) * Sqrt[omega * mu * sigma / 2]

a[rs_, k_, mu_] := 3 * rs / (2 * mu0 * d[rs, k, mu])

d[rs_, k_, mu_] :=
 BesselJ[1, k * rs] / mu0 + (k * rs * BesselJ[0, k * rs] - BesselJ[1, k * rs]) / mu

b[r_, k_, mu_] := r^3 BesselJ[1, k * r] / (d[r, k, mu, d] * mu0) -
   (k * r * BesselJ[0, k * r] - BesselJ[1, k * r]) / (2 * mu)
```

■ Define material parameters, frequency, external field

■ Copper sphere

```
omega = N[109.89 * 2 * Pi]
sigma = 56.82 * 10^6
mu = 1 * mu0
rs = 0.00365
B = 5.17
```

```
690.459
```

```
5.682 10^7
```

```
1.25664 10^-6
```

```
0.00365
```

```
5.17
```

■ Iron sphere

```
omega = N[50 * 2 * Pi]
sigma = 1 * 10^7
mu = 20 * mu0
rs = 0.05
B = 1
```

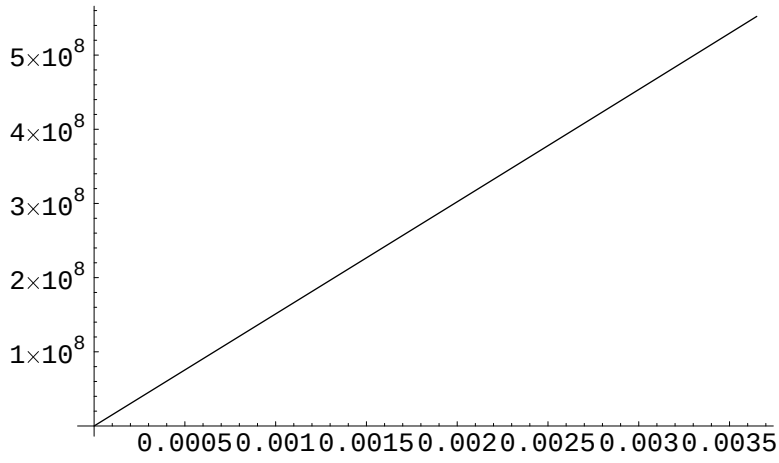
■ Calculate eddy current density

```
j[r_, rs_, theta_, omega_, mu_, sigma_, B_] :=
 -I * B * omega * sigma * aphi[r, rs, theta, omega, mu, sigma]

js[r_] := j[r, rs, N[Pi / 2], omega, mu, sigma, B]
```

■ Plot eddy current density

```
Plot[Abs[j[r, rs, N[Pi / 2], omega, mu, sigma, B]], {r, 0, rs}]
```




```
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```

■ Calculate magnetic moment and magnetization

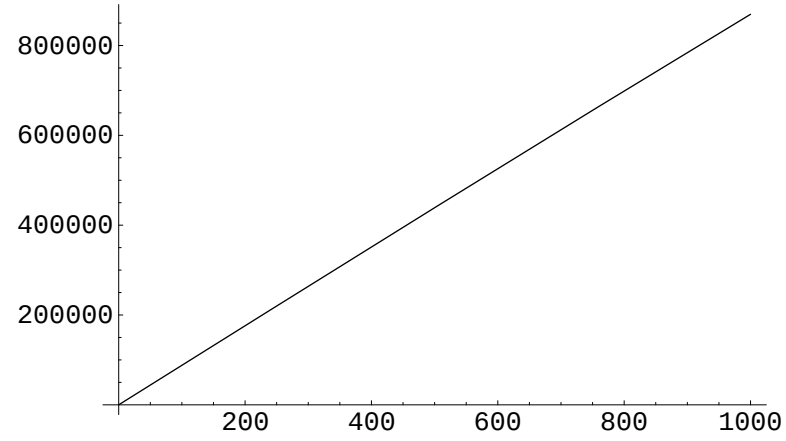
```
moment[rs_, omega_, mu_, sigma_, B_] := NIntegrate[
  r * r^2 * Pi * Abs[j[r, rs, theta, omega, mu, sigma, B]], {r, 0, rs}, {theta, 0, Pi}]

M[rs_, omega_, mu_, sigma_, B_] := moment[rs, omega, mu, sigma, B] / (4 * Pi * rs^3 / 3)

M[rs, omega, mu, sigma, B]
```

```
604310.
```

```
Plot[M[rs, omega, mu, sigma, B], {omega, 0, 1000}, PlotPoints -> 5, PlotDivision -> 1]
```




```
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```
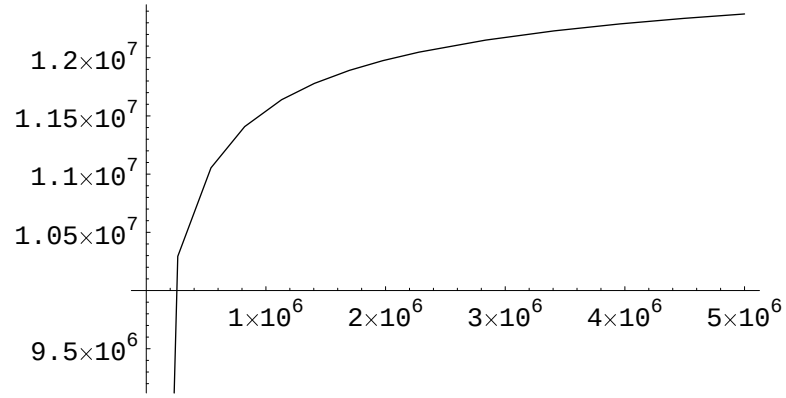

```
Plot[M[rs, omega, mu, sigma, B], {omega, 0, 5000000}, PlotPoints -> 10,
 PlotDivision -> 1]
```




```
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```

■ Simple integration formula for linear dependence of eddy current density on radius

```
Abs[j[rs, rs, N[Pi / 2], omega, mu, sigma, B]] * 6 * rs / 20
```

```
604611.
```

■ Print results in table form

```
TableForm[{atab = Table[a, {a, 0, rs, N[rs / 108]}], Abs[jres = Map[js, atab]] / 10^6,
  Re[jres] / 10^6, Im[jres] / 10^6}, TableDirections -> {Row, Column},
 TableHeadings -> {{"r", "Abs[j] (MA/m^1)", "Re[j] (MA / m^1)", "Im[j] (MA / m^1)"}}]
```