John Waczak

Mathematica code for SHO based off of Dr. Tate's "Shooting Method" used in class 1/10/18

In[1]:=
```
SetOptions[Plot,
  PlotStyle → {Blue, AbsoluteThickness[2], Dashed},
  ImageSize → 500, AxesStyle →
   Directive[FontFamily → "Arial", FontSize → 18,
    Black, AbsoluteThickness[0.5], Arrowheads[0.04]]];
```

In[11]:=
```
m = 1
ω = 1
ℏ = 1
```

Out[11]= 1

Out[12]= 1

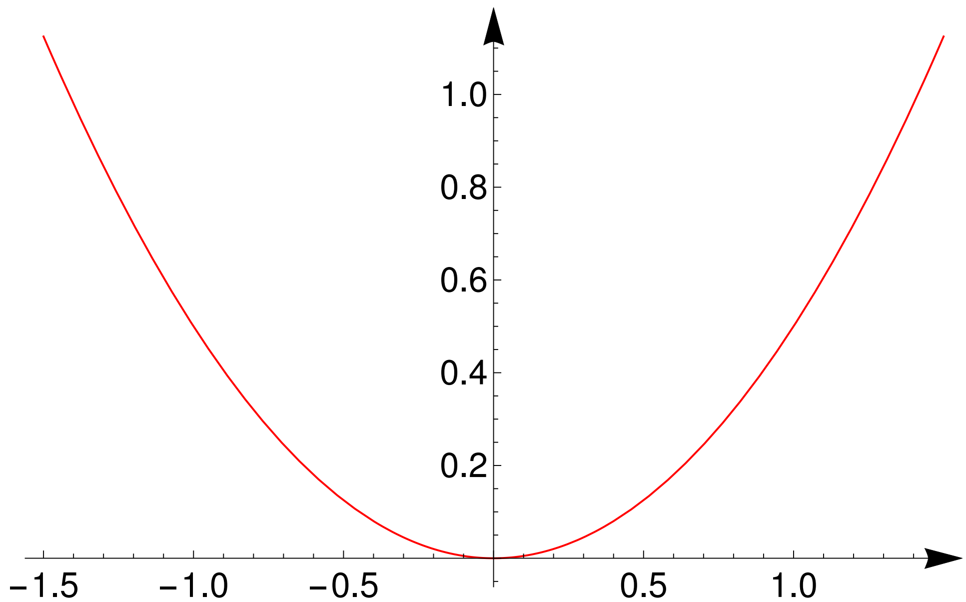
Out[13]= 1

In[14]:=
```
v[x_] := (1/2)*m*ω^2*x^2;
```

Here we graph the harmonic potential

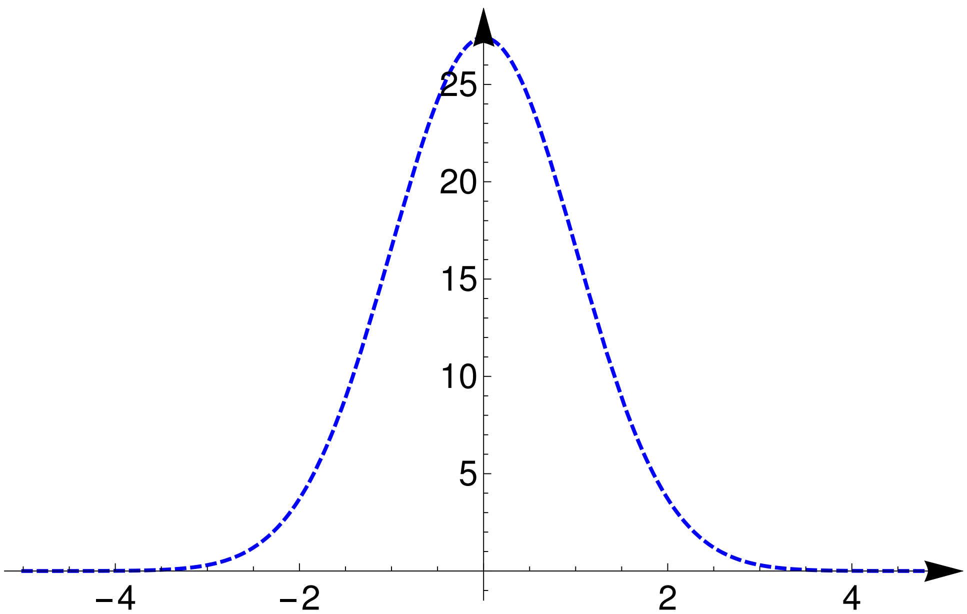
In[28]:=
```
Plot[v[x], {x, -1.5, 1.5},
 PlotStyle -> {Red, AbsoluteThickness[1]}]
```

Out[28]=



Now we choose an energy of 0.5 (because we have sent m, ω, and $\hbar$ to 1 we expect the ground state to have an energy of $\hbar\omega(n + 1/2)$ with n =0)

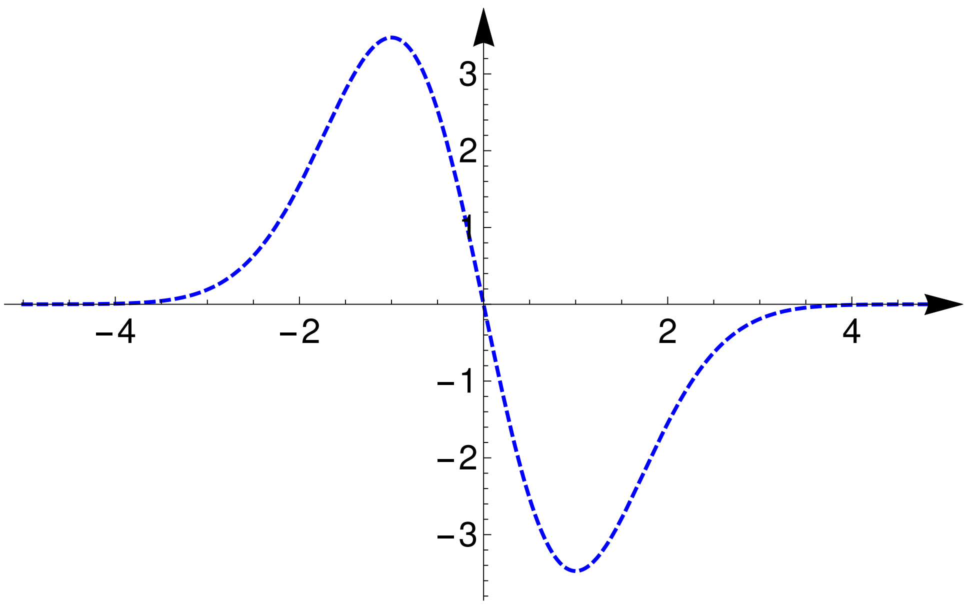
In[29]:=
```
energy = 0.5;
xMax = 5;
solution = NDSolve[
   {psi''[x] == -2 (energy - v[x]) psi[x], psi[-xMax] == 0,
    psi'[-xMax] == 0.001}, psi, {x, -xMax, xMax}];
Plot[psi[x] /. solution, {x, -xMax, xMax}]
```

Out[32]=


Now we find the second eigenstate to have an energy of 1.5 in our units

In[37]:=
```
energy = 1.5;
xMax = 5;
solution = NDSolve[
   {psi''[x] == -2 (energy - v[x]) psi[x], psi[-xMax] == 0,
    psi'[-xMax] == 0.001}, psi, {x, -xMax, xMax}];
Plot[psi[x] /. solution, {x, -xMax, xMax}]
```

Out[40]=



Now, going back to the ground state, we can see how sensitive the system is as an increase of one ten thousandth was enough make the solution blow up to infinity.

In[53]:=
```
energy = 0.50001;
xMax = 5;
solution = NDSolve[
   {psi''[x] == -2 (energy - v[x]) psi[x], psi[-xMax] == 0,
    psi'[-xMax] == 0.001}, psi, {x, -xMax, xMax}];
Plot[psi[x] /. solution, {x, -xMax, xMax}]
```

Out[56]=