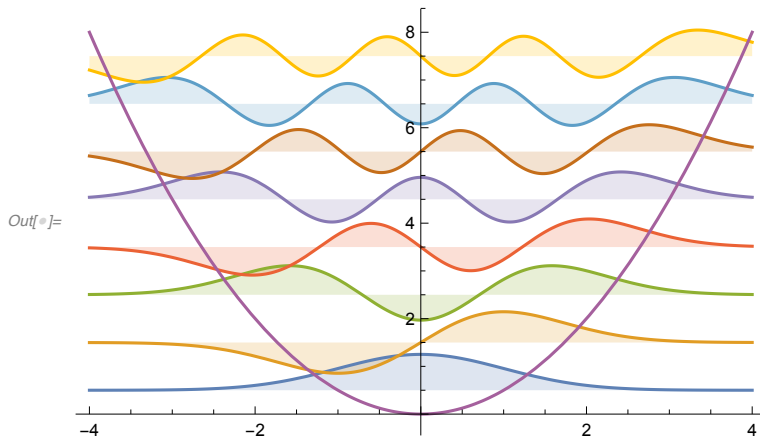


```
In[ ]:= SetDirectory[NotebookDirectory[]];
Import["init.wl"];
```

## Harmonic Oscillator

```
In[ ]:= f[n_, x_] := ((1/Pi)^(1/4) HermiteH[n, x]) / (E^(x^2/2) Sqrt[2^n n!])
Plot[Evaluate@
Append[Table[f[n, x] + n + 1/2, {n, 0, 7}], x^2/2],
{x, -4, 4}, Filling -> Table[n -> n - 1/2, {n, 1, 8}]]
```



## Particle in finite well

```
In[ ]:= subs = {ρ -> Sqrt[-2 m en] / ħ, k -> Sqrt[2 m (en + Vo)]};
φ1[x_] := l1 Exp[ρ x];
φ2s[x_] := w1 Cos[k x];
φ2a[x_] := w1 Sin[k x];
φ3[x_] := r2 Exp[-ρ x];
```

```
In[ ]:= sym = {φ1[-a] - φ2s[-a] == 0, (D[φ1[x], x] - D[φ2s[x], x] == 0) /. x -> -a}
```

```
Out[ ]:= {e^(-a ρ) l1 - w1 Cos[a k] == 0, e^(-a ρ) l1 ρ - k w1 Sin[a k] == 0}
```

```
In[ ]:= asym = {φ1[-a] - φ2a[-a] == 0, (D[φ1[x], x] - D[φ2a[x], x] == 0) /. x -> -a}
```

```
Out[ ]:= {e^(-a ρ) l1 + w1 Sin[a k] == 0, e^(-a ρ) l1 ρ - k w1 Cos[a k] == 0}
```

```
In[ ]:= subs = {ρ -> Sqrt[-2 m en] / ħ, k -> Sqrt[2 m (en + Vo)]};
```

```
f1[en_] := Sqrt[-en / (en + Vo)];
```

```
fs[en_] := Tan[a Sqrt[2 m (en + Vo)] / ħ] /. subs;
```

```
fa[en_] := -Cot[a Sqrt[2 m (en + Vo)] / ħ] /. subs;
```

```
params = {a -> 2, m -> 1, ħ -> 1, Vo -> 10};
```

```
rs0 = FindRoot[(f1[en] - fs[en] == 0) /. params, {en, -9.999}] // Chop;
```

```
rs1 = FindRoot[(f1[en] - fs[en] == 0) /. params, {en, -8}] // Chop;
```

```
rs2 = FindRoot[(f1[en] - fs[en] == 0) /. params, {en, -4}] // Chop;
```

```

ra1 = FindRoot[(f1[en] - fa[en] == 0) /. params, {en, -9}] // Chop;
ra2 = FindRoot[(f1[en] - fa[en] == 0) /. params, {en, -6}] // Chop;
ra3 = FindRoot[(f1[en] - fa[en] == 0) /. params, {en, -2}] // Chop;

tab1 = {{en /. rs0, S}, {en /. rs1, S},
        {en /. rs2, S}, {en /. ra1, A}, {en /. ra2, A}, {en /. ra3, A}};
tab1 // TableForm

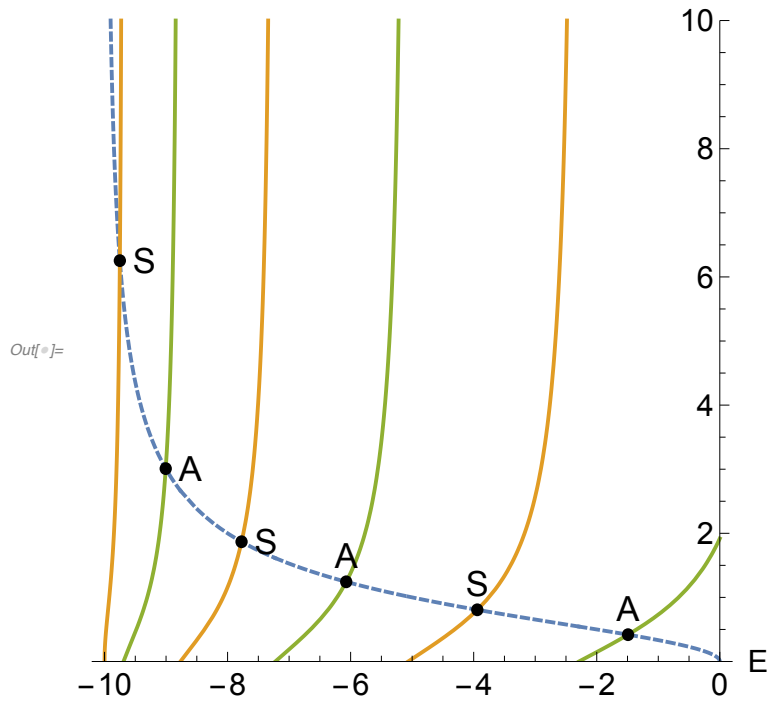
p1 = {en /. rs0, f1[en /. rs0] /. params};
p2 = {en /. rs1, f1[en /. rs1] /. params};
p3 = {en /. rs2, f1[en /. rs2] /. params};
p4 = {en /. ra1, f1[en /. ra1] /. params};
p5 = {en /. ra2, f1[en /. ra2] /. params};
p6 = {en /. ra3, f1[en /. ra3] /. params};

Plot[{f1[x] /. params,
      fs[x] /. params,
      fa[x] /. params
}, {x, -10, 0},
PlotRange -> {0, 10},
PlotStyle -> {{Thick, Dashing[{0.01}]}, Thick, Thick},
AxesLabel -> {"E", None},
LabelStyle -> 16,
AspectRatio -> 1,
Exclusions -> {Sin[2  $\sqrt{2(x+10)}$ ] == 0, Cos[2  $\sqrt{2(x+10)}$ ] == 0},
PlotPoints -> 75,
Epilog -> {
  Disk[{en /. rs0, f1[en /. rs0] /. params}, 0.1],
  Disk[{en /. rs1, f1[en /. rs1] /. params}, 0.1],
  Disk[{en /. rs2, f1[en /. rs2] /. params}, 0.1],
  Disk[{en /. ra1, f1[en /. ra1] /. params}, 0.1],
  Disk[{en /. ra2, f1[en /. ra2] /. params}, 0.1],
  Disk[{en /. ra3, f1[en /. ra3] /. params}, 0.1],
  Style[Text["S", p1 + {0.4, 0}], 18],
  Style[Text["S", p2 + {0.4, 0}], 18],
  Style[Text["S", p3 + {0, 0.4}], 18],
  Style[Text["A", p4 + {0.4, 0}], 18],
  Style[Text["A", p5 + {0, 0.4}], 18],
  Style[Text["A", p6 + {0, 0.4}], 18],
  AxesStyle -> Thick
}]

```

Out[ ]//TableForm=

-9.7507	S
-7.77297	S
-3.94146	S
-9.00542	A
-6.07186	A
-1.49125	A

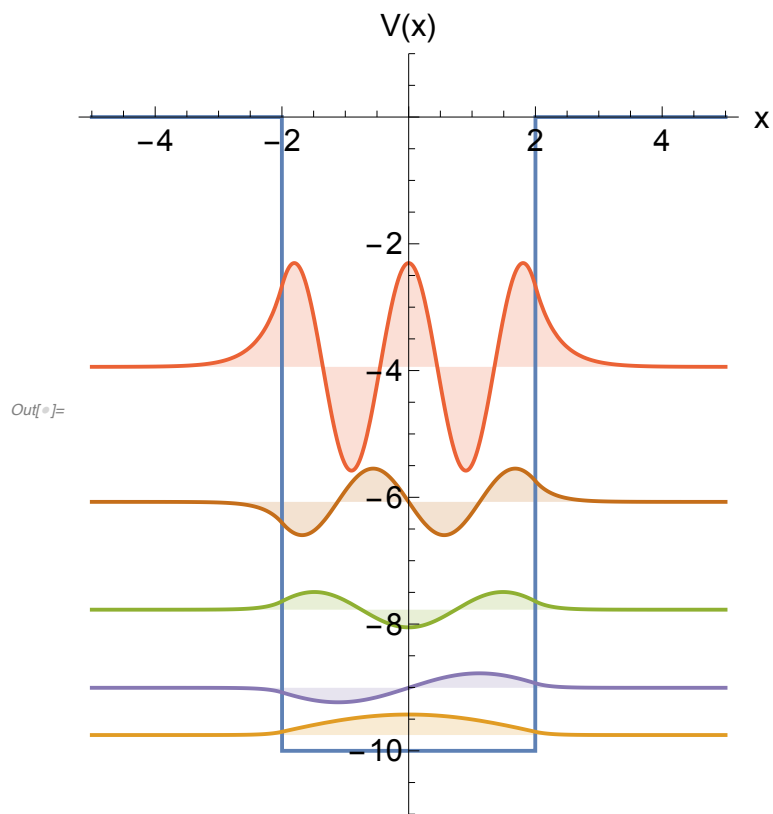


```

In[ ]:= subs = {ρ →  $\sqrt{-2 m \epsilon n} / \hbar$ , k →  $\sqrt{2 m (\epsilon n + V_0)}$ } /. params;
ψs[x_] := Which[
  Abs[x] < a, B Cos[  $\sqrt{2 m (\epsilon n + V_0)}$  x ],
  x ≥ a, Exp[ -x  $\sqrt{-2 m \epsilon n}$  ],
  x ≤ -a, Exp[ x  $\sqrt{-2 m \epsilon n}$  ] ] /. {B → Sec[ a  $\sqrt{2 m (\epsilon n + V_0)}$  ] Exp[ -a  $\sqrt{-2 m \epsilon n}$  ] }
ψa[x_] := Which[
  Abs[x] ≤ a, B Sin[  $\sqrt{2 m (\epsilon n + V_0)}$  x ] /. subs,
  x > a, Exp[ -x  $\sqrt{-2 m \epsilon n}$  ],
  x < -a, -Exp[ x  $\sqrt{-2 m \epsilon n}$  ] ] /.
  {B → Csc[ a  $\sqrt{2 m (\epsilon n + V_0)}$  ] /  $\hbar$  Exp[ -a  $\sqrt{-2 m \epsilon n} / \hbar$  ] }
V[x_] := If[Abs[x] < a, -V0, 0];

amp = 350;
plotWF = Plot[{
  V[x] /. params,
  (amp ψs[x] + en) /. Join[params, rs0],
  (amp ψs[x] + en) /. Join[params, rs1],
  (amp ψs[x] + en) /. Join[params, rs2],
  (amp ψa[x] + en) /. Join[params, ra1],
  (amp ψa[x] + en) /. Join[params, ra2]
}, {x, -5, 5},
Filling → {
  2 -> en /. Join[params, rs0],
  3 -> en /. Join[params, rs1],
  4 -> en /. Join[params, rs2],
  5 -> en /. Join[params, ra1],
  6 -> en /. Join[params, ra2],
},
PlotRange → {1, -11},
LabelStyle → 16,
AspectRatio → {1},
PlotStyle → Thick,
AxesLabel → {"x", "V(x)"}];
Show[plotWF]

```



## DOS versus dimensionality

$\text{In}[*]:= \rho[d_, x_] := 2^{(d/2-1)} d \pi^{(d/2-2)} \left( \sqrt{m x} / \hbar \right)^d / \left( x \text{Gamma}\left[\left(d/2 + 1\right)\right] \right)$

```
Plot[
  {ρ[1, x] /. {m → 1, ħ → 1},
   ρ[2, x] /. {m → 1, ħ → 1},
   ρ[3, x] /. {m → 1, ħ → 1},
   ρ[4, x] /. {m → 1, ħ → 1},
   ρ[5, x] /. {m → 1, ħ → 1}
  ], {x, 0, 1},
  PlotStyle → Thick,
  AspectRatio → 1,
  AxesLabel → {"E (a.u)", "ρd(E)"},
  LabelStyle → 16,
  Epilog → {
    Style[Text["1D", {0.8, 0.3}], 16],
    Style[Text["2D", {0.8, 0.8}], 16],
    Style[Text["3D", {0.8, 1.75}], 16],
    Style[Text["4D", {0.8, 3.4}], 16],
    Style[Text["5D", {0.8, 6.0}], 16]
  }
]
```

