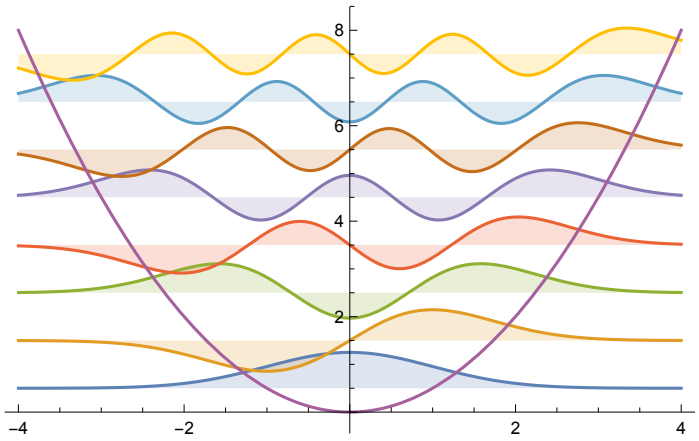
```
In[•]:= SetDirectory[NotebookDirectory[]];
        Import["init.wl"];
```

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}]]
```

Out[•]=



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)]};
```

$$f1[en\_] := \sqrt{\frac{-en}{en + Vo}};$$

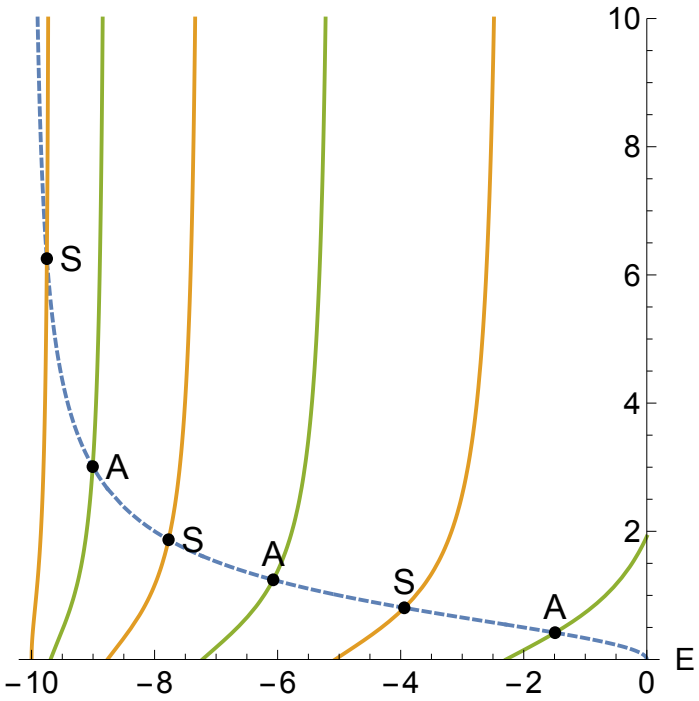
```
        fs[en_] := Tan[a Sqrt[2 m (en + Vo)]/ħ] /. subs;
        fa[en_] := -Cot[a Sqrt[2 m (en + Vo)]/ħ] /. subs;
        params = {a → 2, m → 1, ħ → 1, Vo → 10};

        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 √(2 (x + 10))] == 0, Cos[2 √(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=

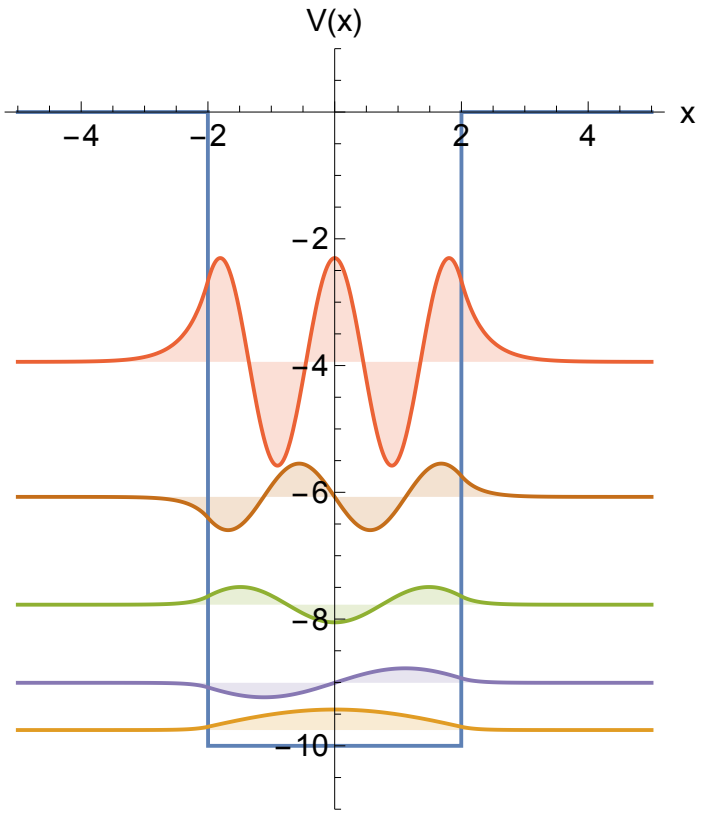
−9.7507	S
−7.77297	S
−3.94146	S
−9.00542	A
−6.07186	A
−1.49125	A

Out[•]=



```
In[•]:= subs = {ρ → √(-2 m en) / ħ, k → √(2 m (en + Vo))} /. params;
ψs[x_] := Which[
        Abs[x] < a, B Cos[ √(2 m (en + Vo)) x],
        x ≥ a, Exp[-x √(-2 m en) ],
        x ≤ -a, Exp[ x √(-2 m en)]] /. {B → Sec[a √(2 m (en + Vo)) ] Exp[-a √(-2 m en) ]}
ψa[x_] := Which[
        Abs[x] ≤ a, B Sin[ √(2 m (en + Vo)) x] /. subs,
        x > a, Exp[-x √(-2 m en)],
        x < -a, -Exp[ x √(-2 m en)]] /.
  {B → Csc[a √(2 m (en + Vo)) / ħ] Exp[-a √(-2 m en) / ħ ]}
V[x_] := If[Abs[x] < a, -Vo, 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]
```

Out[ ]=



DOS versus dimensionality

In[•]:=
```
ρ[d_, x_] := 2^(d/2-1) d π^(d/2-2) (√(m x) / ħ)^d / (x Gamma[(d / 2 + 1)])
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]
  }]
```

Out[•]=