```
> restart:
```

```
> # Die niedrigsten beiden Zustaende des HO (nicht normiert).

phi_0 := exp(-a*x^2);
phi_1 := exp(-a*x^2) * x;
```

$$\phi 0 := e^{-a x^2}$$
$$\phi 1 := e^{-a x^2} x \qquad (1)$$

```
> # Das harmonische Potential und die niedrigsten beiden Energie-
Eigenwerte.

V := (1/2) * m * omega^2 * x^2;

E_0 := h*omega/2;
E_1 := 3*h*omega/2;
```

$$V := \frac{1}{2} m \omega^2 x^2$$
$$E\_0 := \frac{1}{2} h \omega$$
$$E\_1 := \frac{3}{2} h \omega \qquad (2)$$

```
> # Einsetzen in die SG  -->  a = m * omega / (2 * h).

simplify(
  (-h^2/(2*m)) * diff(diff(phi_0, x), x) + V * phi_0 - E_0 * phi_0
  );
```

$$-\frac{1}{2} \frac{e^{-a x^2} \left(-2 h^2 a + 4 h^2 a^2 x^2 - m^2 \omega^2 x^2 + h \omega m\right)}{m} \qquad (3)$$

```
> a := m*omega/(2*h);
```

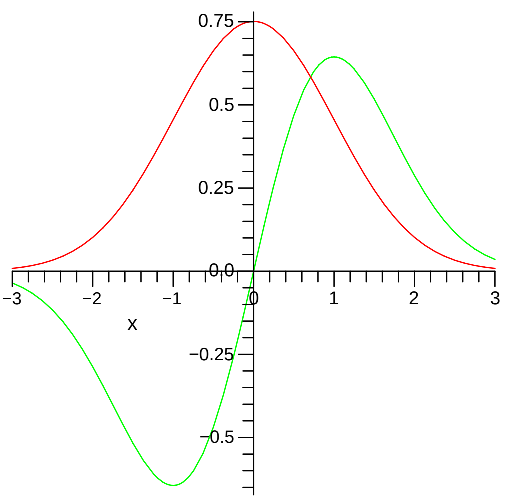
$$a := \frac{1}{2} \frac{m \omega}{h} \qquad (4)$$

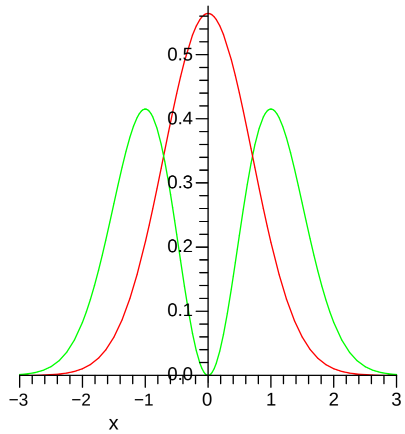
```
> # Testen der niedrigsten beiden Zustaende (einsetzen in die SG).

simplify(
  (-h^2/(2*m)) * diff(diff(phi_0, x), x) + V * phi_0 - E_0 * phi_0
  );

simplify(
  (-h^2/(2*m)) * diff(diff(phi_1, x), x) + V * phi_1 - E_1 * phi_1
  );
```

$$0$$
$$0 \qquad (5)$$

```
> # Norm der niedrigsten beiden Zustaende.

assume(m>0):
assume(omega>0):
assume(h>0):

norm_0 := simplify(sqrt(int(phi_0*phi_0, x=-infinity..infinity)));
norm_1 := simplify(sqrt(int(phi_1*phi_1, x=-infinity..infinity)));


# Wellenfunktionen.

plot([
  subs(h=1.0, m=1.0, omega=1.0, phi_0/norm_0),
  subs(h=1.0, m=1.0, omega=1.0, phi_1/norm_1)
  ], x=-3.0..+3.0);


# Aufenthaltswahrscheinlichkeiten.

plot([
  subs(h=1.0, m=1.0, omega=1.0, conjugate(phi_0/norm_0) *
phi_0/norm_0),
  subs(h=1.0, m=1.0, omega=1.0, conjugate(phi_1/norm_1) *
phi_1/norm_1)
  ], x=-3.0..+3.0);
```

$$norm\_0 := \frac{h\sim^{1/4} \pi^{1/4}}{m\sim^{1/4} \omega\sim^{1/4}}$$
$$norm\_1 := \frac{1}{2} \frac{\sqrt{2}\, h\sim^{3/4} \pi^{1/4}}{m\sim^{3/4} \omega\sim^{3/4}}$$



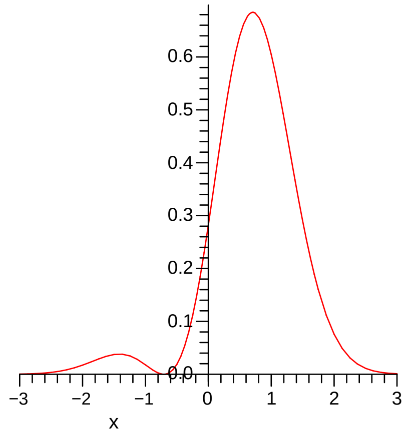


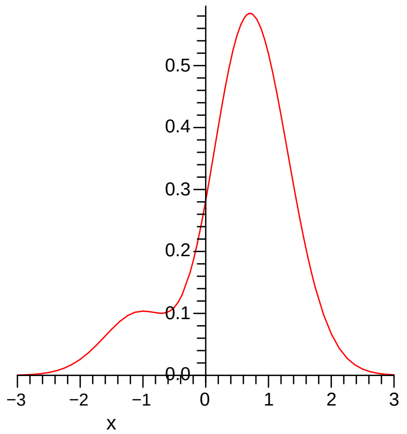

```
> # Mischzustand der niedrigsten beiden Zustaende.

psi :=
  exp(-I*E_0*t) * (1/sqrt(2)) * phi_0 / norm_0 +
  exp(-I*E_1*t) * (1/sqrt(2)) * phi_1 / norm_1;
```

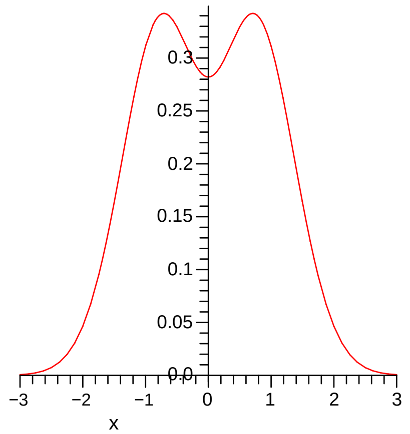
$$\psi := \frac{1}{2} \frac{e^{-\frac{1}{2} I \omega\sim h\sim t} \sqrt{2}\, e^{-\frac{1}{2} \frac{m\sim \omega\sim x^2}{h\sim}} m\sim^{1/4} \omega\sim^{1/4}}{h\sim^{1/4} \pi^{1/4}} + \frac{e^{-\frac{3}{2} I \omega\sim h\sim t} e^{-\frac{1}{2} \frac{m\sim \omega\sim x^2}{h\sim}} x\, m\sim^{3/4} \omega\sim^{3/4}}{h\sim^{3/4} \pi^{1/4}} \qquad (6)$$

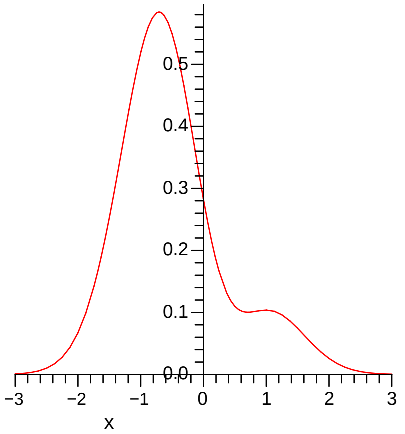
```
> # Zeitentwicklung der Aufenthaltswahrscheinlichkeit des
Mischzustandes.

plot(
```

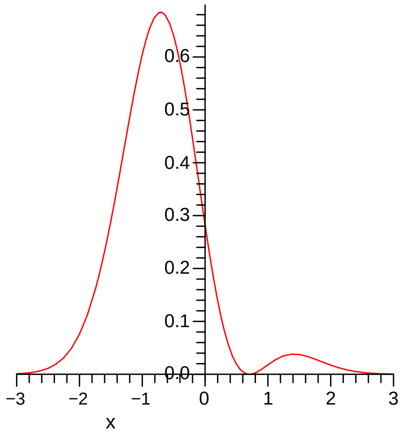
```
  subs(t=0.000*(2*Pi), h=1.0, m=1.0, omega=1.0, conjugate(psi) *
psi)
  , x=-3.0..+3.0);

plot(
  subs(t=0.125*(2*Pi), h=1.0, m=1.0, omega=1.0, conjugate(psi) *
psi)
  , x=-3.0..+3.0);

plot(
  subs(t=0.250*(2*Pi), h=1.0, m=1.0, omega=1.0, conjugate(psi) *
psi)
  , x=-3.0..+3.0);

plot(
  subs(t=0.375*(2*Pi), h=1.0, m=1.0, omega=1.0, conjugate(psi) *
psi)
  , x=-3.0..+3.0);

plot(
  subs(t=0.500*(2*Pi), h=1.0, m=1.0, omega=1.0, conjugate(psi) *
psi)
  , x=-3.0..+3.0);
```








0.5
0.4
0.3
0.2
0.1
0.0
−3
−2
−1
0
1
2
3
x


0.6
0.5
0.4
0.3
0.2
0.1
0.0
−3
−2
−1
0
1
2
3
x

>