

In[90]:= **DateList** []

Out[90]:= {2009, 11, 9, 12, 8, 24.878523}

Harmonic oscillator

$$\mathfrak{E}[n_][x_]:= \frac{\left(\frac{\alpha}{\pi}\right)^{1/4} \text{HermiteH}[n, \sqrt{\alpha} x] \text{Exp}[-\alpha x^2/2]}{\sqrt{2^n n!}}$$

$$\text{pm}[f_]:= \frac{\hbar \partial_x f}{i}$$

pm[$\mathfrak{E}[n][x]$]

$$-i \hbar \left(\frac{2 e^{-\frac{x^2 \alpha}{2}} n \alpha^{3/4} \text{HermiteH}[-1+n, x \sqrt{\alpha}]}{\pi^{1/4} \sqrt{2^n n!}} - \frac{e^{-\frac{x^2 \alpha}{2}} x \alpha^{5/4} \text{HermiteH}[n, x \sqrt{\alpha}]}{\pi^{1/4} \sqrt{2^n n!}} \right)$$

pm[**pm**[$\mathfrak{E}[n][x]$]]

$$-\hbar^2 \left(\frac{4 e^{-\frac{x^2 \alpha}{2}} (-1+n) n \alpha^{5/4} \text{HermiteH}[-2+n, x \sqrt{\alpha}]}{\pi^{1/4} \sqrt{2^n n!}} - \frac{4 e^{-\frac{x^2 \alpha}{2}} n x \alpha^{7/4} \text{HermiteH}[-1+n, x \sqrt{\alpha}]}{\pi^{1/4} \sqrt{2^n n!}} - \frac{e^{-\frac{x^2 \alpha}{2}} \alpha^{5/4} \text{HermiteH}[n, x \sqrt{\alpha}]}{\pi^{1/4} \sqrt{2^n n!}} + \frac{e^{-\frac{x^2 \alpha}{2}} x^2 \alpha^{9/4} \text{HermiteH}[n, x \sqrt{\alpha}]}{\pi^{1/4} \sqrt{2^n n!}} \right)$$

pAVE = **Table**[**Integrate**[$\mathfrak{E}[n][x]$ **pm**[$\mathfrak{E}[n][x]$], {x, - ∞ , ∞ }, **Assumptions** \rightarrow **Re**[α] > 0], {n, 0, 5}]

{0, 0, 0, 0, 0, 0}

p2AVE = **Table**[**Integrate**[$\mathfrak{E}[n][x]$ **pm**[**pm**[$\mathfrak{E}[n][x]$]], {x, - ∞ , ∞ }, **Assumptions** \rightarrow **Re**[α] > 0], {n, 0, 5}]

$$\left\{ \frac{\alpha \hbar^2}{2}, \frac{3 \alpha \hbar^2}{2}, \frac{5 \alpha \hbar^2}{2}, \frac{7 \alpha \hbar^2}{2}, \frac{9 \alpha \hbar^2}{2}, \frac{11 \alpha \hbar^2}{2} \right\}$$

xAVE = **Table**[**Integrate**[$\mathfrak{E}[n][x]$ x $\mathfrak{E}[n][x]$, {x, - ∞ , ∞ }, **Assumptions** \rightarrow **Re**[α] > 0], {n, 0, 5}]

{0, 0, 0, 0, 0, 0}

x2AVE = **Table**[**Integrate**[$\mathfrak{E}[n][x]$ x^2 $\mathfrak{E}[n][x]$, {x, - ∞ , ∞ }, **Assumptions** \rightarrow **Re**[α] > 0], {n, 0, 5}]

$$\left\{ \frac{1}{2\alpha}, \frac{3}{2\alpha}, \frac{5}{2\alpha}, \frac{7}{2\alpha}, \frac{9}{2\alpha}, \frac{11}{2\alpha} \right\}$$

Sqrt[**p2AVE** **x2AVE**]

$$\left\{ \frac{\sqrt{\hbar^2}}{2}, \frac{3 \sqrt{\hbar^2}}{2}, \frac{5 \sqrt{\hbar^2}}{2}, \frac{7 \sqrt{\hbar^2}}{2}, \frac{9 \sqrt{\hbar^2}}{2}, \frac{11 \sqrt{\hbar^2}}{2} \right\}$$

kinAVE = **p2AVE** / (2 μ)

$$\left\{ \frac{\alpha \hbar^2}{4 \mu}, \frac{3 \alpha \hbar^2}{4 \mu}, \frac{5 \alpha \hbar^2}{4 \mu}, \frac{7 \alpha \hbar^2}{4 \mu}, \frac{9 \alpha \hbar^2}{4 \mu}, \frac{11 \alpha \hbar^2}{4 \mu} \right\}$$

$$\mathbf{potAVE} = (\mathbf{x2AVE} \mathbf{k} / 2) /. \{\mathbf{k} \rightarrow \hbar^2 \alpha^2 / \mu\}$$

$$\left\{ \frac{\alpha \hbar^2}{4 \mu}, \frac{3 \alpha \hbar^2}{4 \mu}, \frac{5 \alpha \hbar^2}{4 \mu}, \frac{7 \alpha \hbar^2}{4 \mu}, \frac{9 \alpha \hbar^2}{4 \mu}, \frac{11 \alpha \hbar^2}{4 \mu} \right\}$$

$$\mathbf{kinAVE} + \mathbf{potAVE}$$

$$\left\{ \frac{\alpha \hbar^2}{2 \mu}, \frac{3 \alpha \hbar^2}{2 \mu}, \frac{5 \alpha \hbar^2}{2 \mu}, \frac{7 \alpha \hbar^2}{2 \mu}, \frac{9 \alpha \hbar^2}{2 \mu}, \frac{11 \alpha \hbar^2}{2 \mu} \right\}$$