

### Honors Project 13: Vibration in Molecules

The simplest approximate description of vibration in molecules involves functions whose form is dictated by the laws of quantum mechanics to be

$$\psi_n(z) = h_n(z)e^{-z^2/2}, \quad n = 0, 1, 2, \dots$$

where

$$h_0(z) = 1, \quad h_1(z) = 2z, \quad h_2(z) = 4z^2 - 2,$$

and, more generally,

$$h_n(z) = (-1)^n \frac{d^n}{dz^n} e^{-z^2}.$$

#### Problems

1. Generate  $h_3(z)$ ,  $h_4(z)$ , and  $h_5(z)$ .
2. The laws of quantum mechanics applied to this description of vibration tell us that for all integers  $n$ ,

$$z^2\psi_n - \frac{d^2}{dz^2}\psi_n = \frac{E_n}{E_0}\psi_n$$

where  $E_n$  is an energy associated with the  $n$ th wavefunction. Find  $E_n/E_0$  for  $n = 1, 2$ .

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