

## Matrix mechanics 3

From “Lectures on Quantum Mechanics, Second Edition” by Weinberg, p. 154.

Let  $\mathbf{R}$  be the Runge-Lenz vector

$$\mathbf{R} = -\frac{Ze^2\mathbf{x}}{r} + \frac{1}{2m}(\mathbf{p} \times \mathbf{L} - \mathbf{L} \times \mathbf{p}) \quad (4.8.1)$$

where  $\mathbf{L}$  is the angular momentum vector

$$\mathbf{L} = \mathbf{x} \times \mathbf{p}$$

Verify that

$$\mathbf{R}^2 = Z^2e^4 + \frac{2}{m}H(\mathbf{L}^2 + \hbar^2) \quad (4.8.7)$$

where  $H$  is the Hamiltonian

$$H = \frac{\mathbf{p}^2}{2m} - \frac{Ze^2}{r}$$

Verify that  $\mathbf{R}$  and  $\mathbf{R}^2$  commute with  $H$ .

Eigenmath script