1. Spin chain simulation

Use Trotterization

Example: slides 8-9 (Lecture 9)

2. Richardson extrapolation

Slides: 14-15 (Lecture 9)

3. Parameter-shift rule 1

Use the identity: $\pm \cos(x) = \sin(x \pm \pi/2)$

4. Parameter-shift rule 2

a) State the expression for the expectation value

b) Use the hint provided

This property will be useful: $Ae^{Ax} = e^{Ax}A$

Short proof:

$$Ae^{Ax} = (A)\left(1 + \frac{Ax}{1!} + \frac{(Ax)^2}{2!} + \frac{(Ax)^3}{3!} + \dots\right) = A + \frac{A^2x}{1!} + \frac{A^3x}{2!} + \frac{A^4x}{3!} + \dots$$

$$= \left(1 + \frac{Ax}{1!} + \frac{(Ax)^2}{2!} + \frac{(Ax)^3}{3!} + \dots\right)(A) = e^{Ax}A$$

Therefore, the commutative property is satisfied in this case.