

## Solutions

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**2.1** Answer: C. The density is symmetric about  $L/2$  while the perturbation is odd, so the integral cancels.

Compare the rejected options:  $\gamma L$ ;  $\gamma L/2$ ;  $-\gamma L/2$ ; Undefined for every  $n$ . Use the stated model and conditions.

**2.2** Answer: C. The matrix eigenvalues are  $\pm\varepsilon$ . Its vanishing diagonal does not mean vanishing splitting.

Compare the rejected options: 0 and 0;  $\varepsilon$  and  $\varepsilon$ ; 0 and  $2\varepsilon$ ;  $-2\varepsilon$  and  $2\varepsilon$ . Use the stated model and conditions.

**2.3** 0.04.  $\gamma\langle x \rangle = 0.02 \cdot 4/2 = 0.04$  eV.

**2.4** False. Off-diagonal couplings can contribute at second order even when the diagonal expectation cancels.

**3.1** Characteristic equation is  $E^2 - \Delta E - \epsilon^2 = 0$ .  $E_{\pm} = (\Delta \pm \sqrt{\Delta^2 + 4\epsilon^2})/2$ . Expand the lower root:  $E_- \approx -\epsilon^2/\Delta$ . The first-order shift is zero, but off-diagonal mixing produces a negative second-order shift. Award equation, roots, expansion, sign and mixing/validity. At  $\Delta = 0$  use degenerate theory instead.