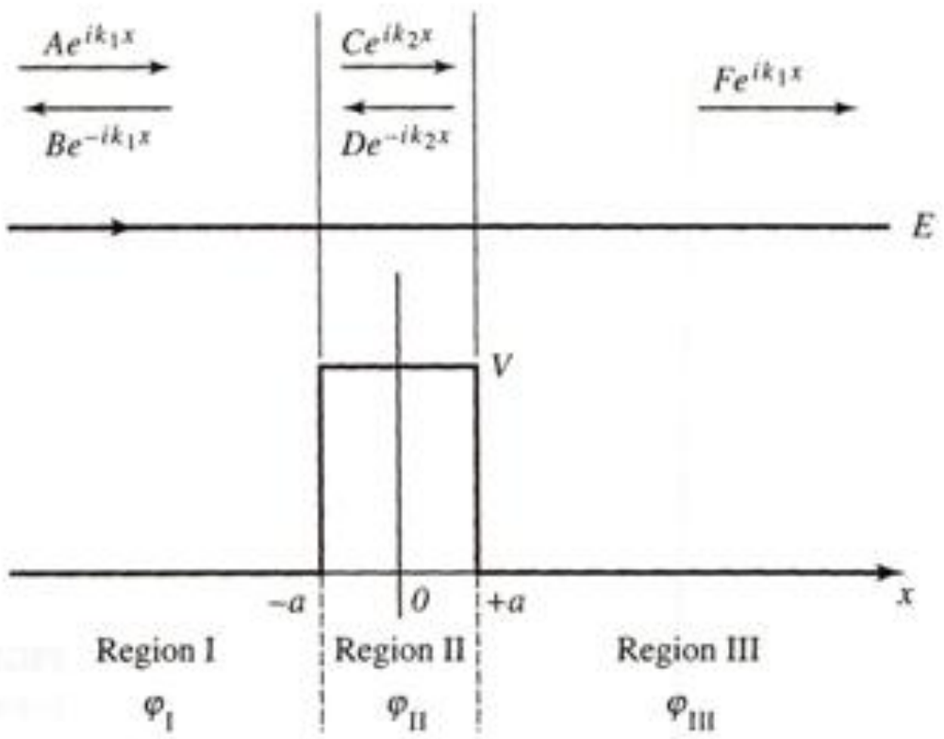
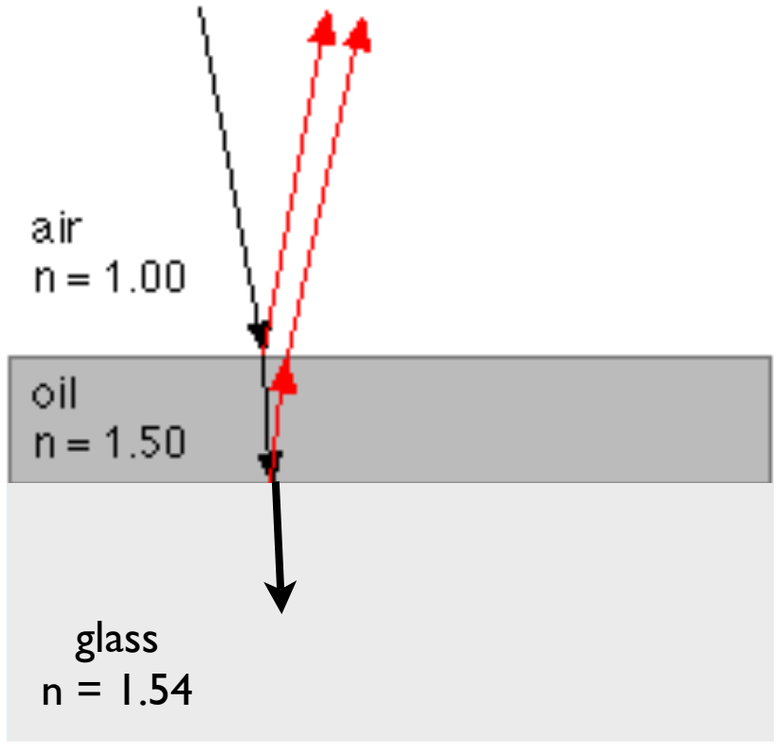
Thin-Film Interference with Electrons





Alex M. Barr

CSAAPT Spring Meeting, 04/22/16

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PHYS-112

- 3rd semester calculus-based physics
- Covers mechanical waves, optics, modern physics
- Most students are in Calc III or D. E.
- Goal is to solve problems graphically while motivating use of D. E.'s

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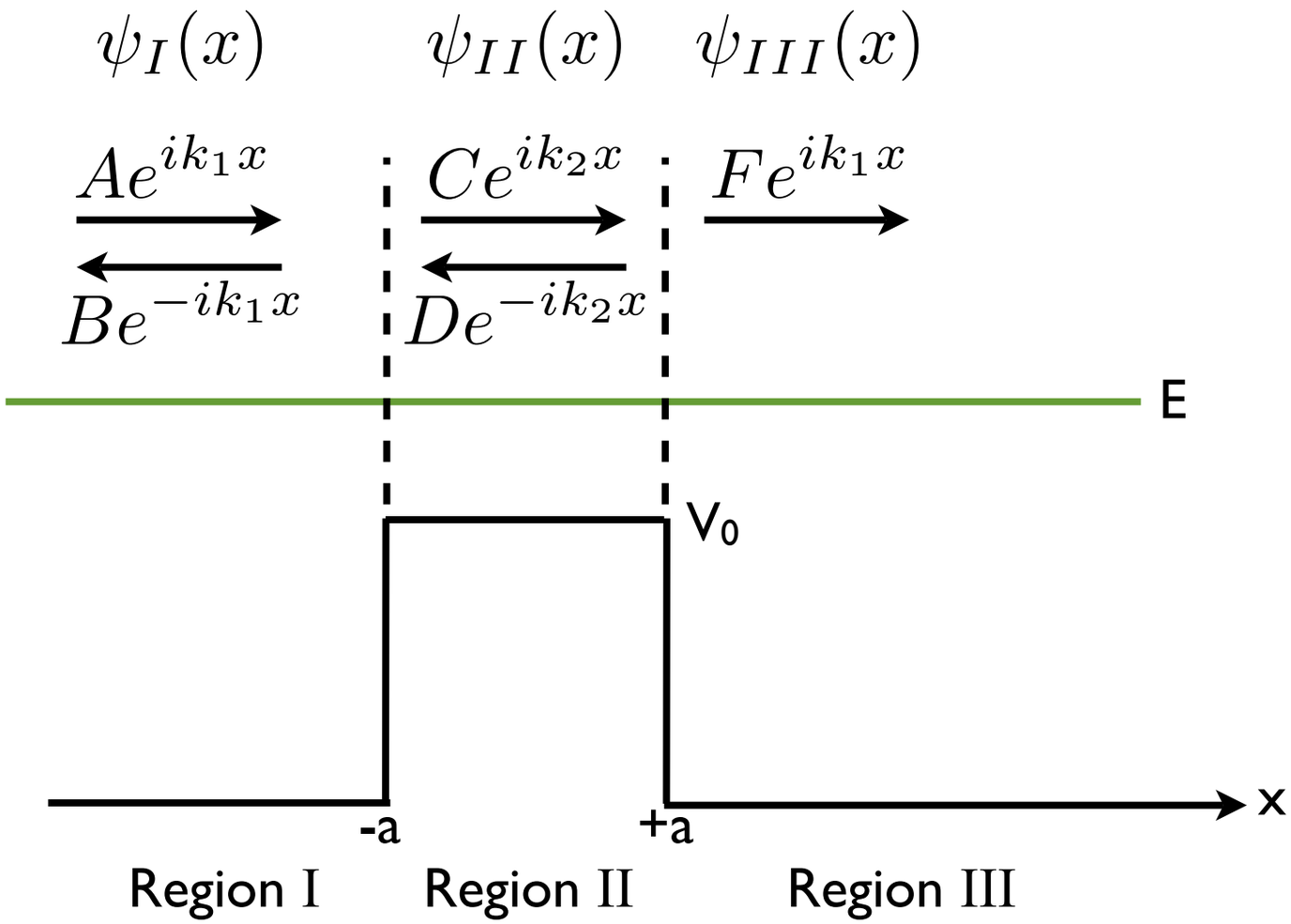
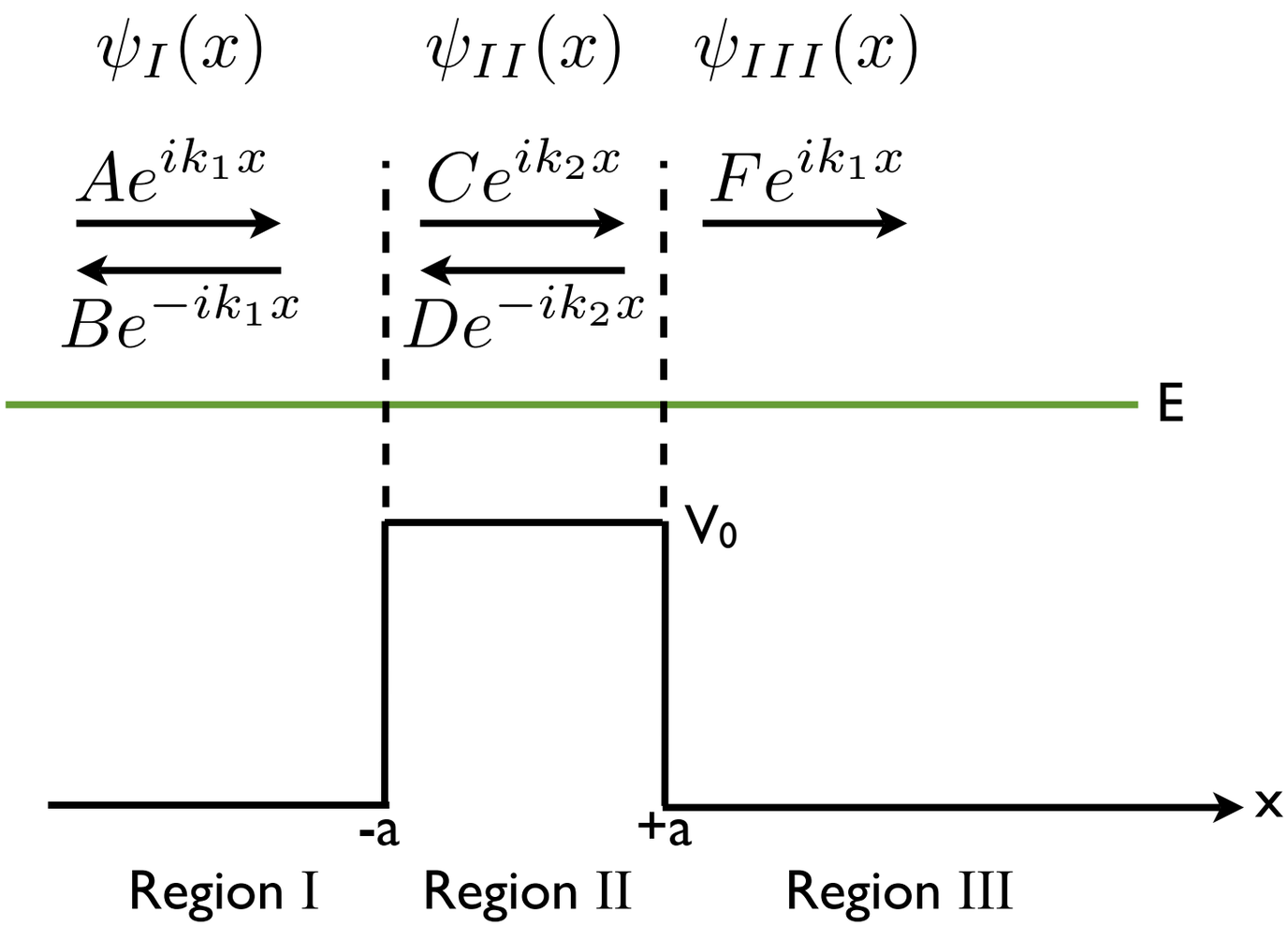
Reflection and transmission from a barrier



Reflection and transmission from a barrier



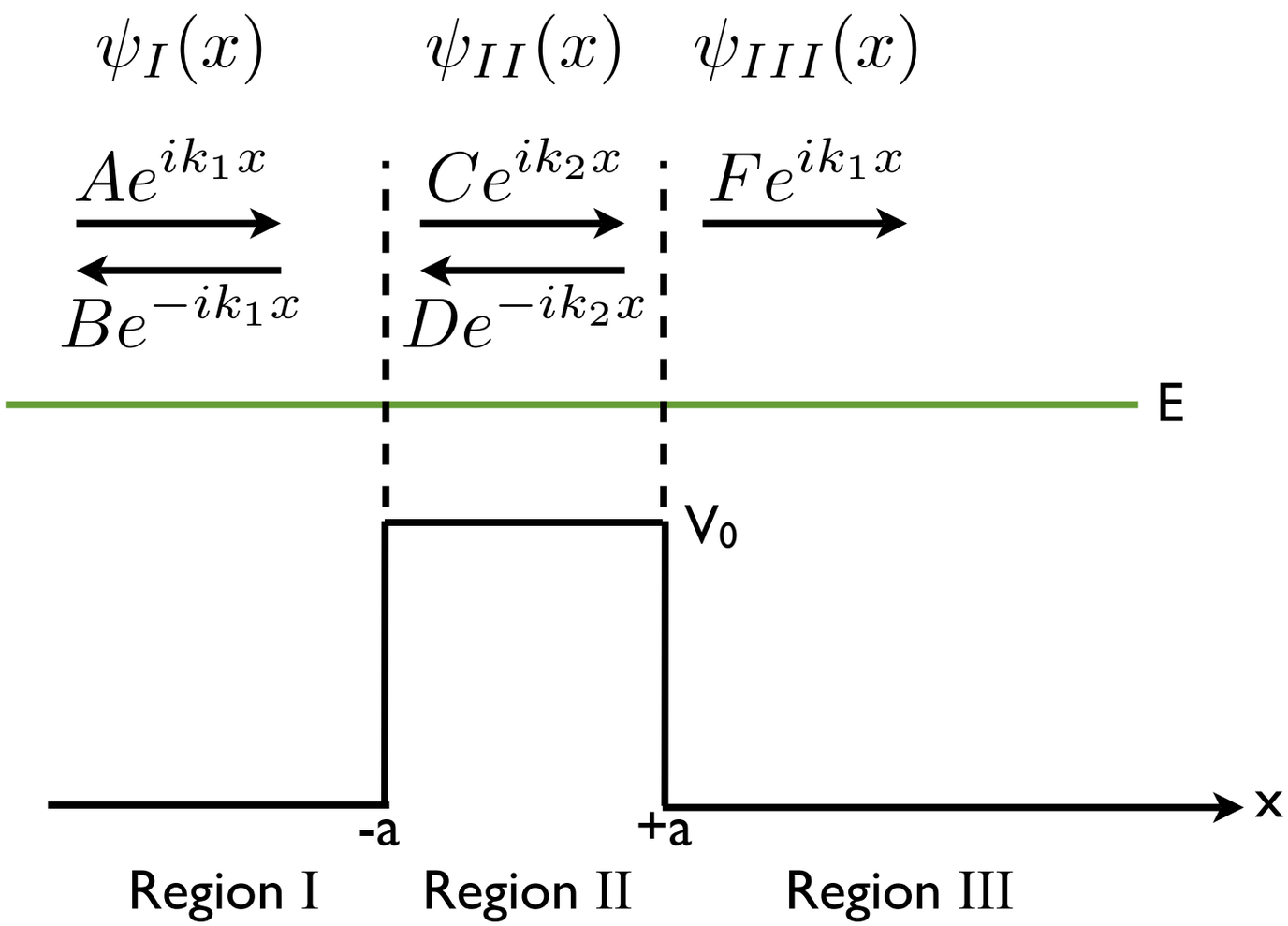
$$\psi_I(-a) = \psi_{II}(-a)$$

$$\left.\frac{d\psi_I}{dx}\right|_{-a} = \left.\frac{d\psi_{II}}{dx}\right|_{-a}$$

$$\psi_{II}(a) = \psi_{III}(a)$$

$$\left.\frac{d\psi_{II}}{dx}\right|_{a} = \left.\frac{d\psi_{III}}{dx}\right|_{a}$$

Reflection and transmission from a barrier



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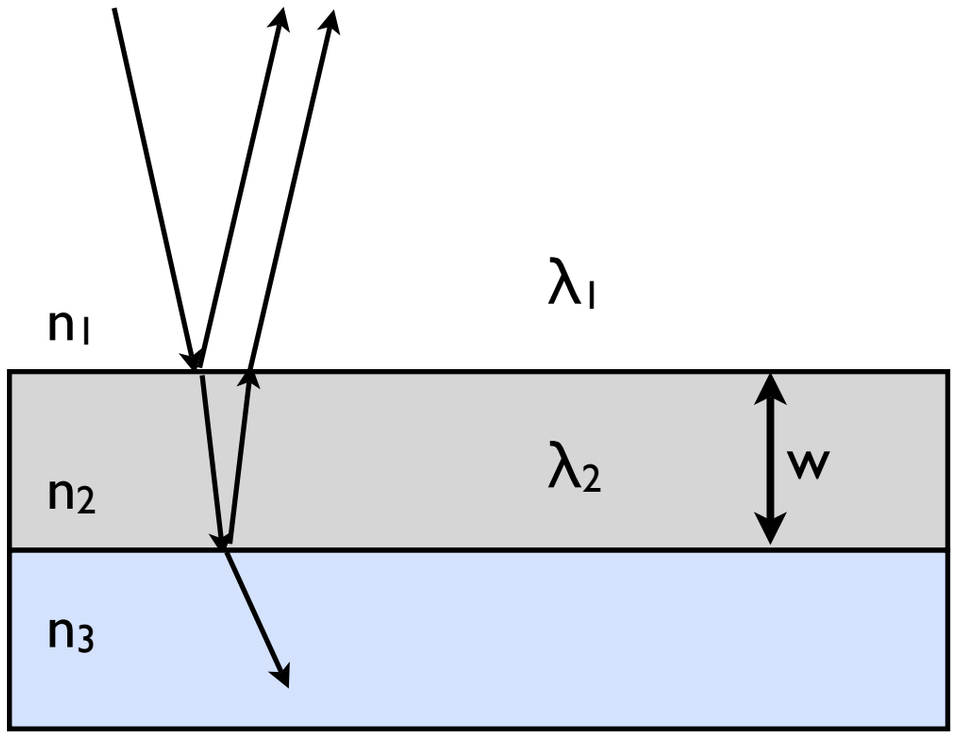
$$\psi_{II}(a) = \psi_{III}(a)$$

$$\left.\frac{d\psi_{II}}{dx}\right|_{a} = \left.\frac{d\psi_{III}}{dx}\right|_{a}$$

$$R = \frac{|B|^2}{|A|^2} \qquad T = \frac{|F|^2}{|A|^2}$$

Thin-film interference with light



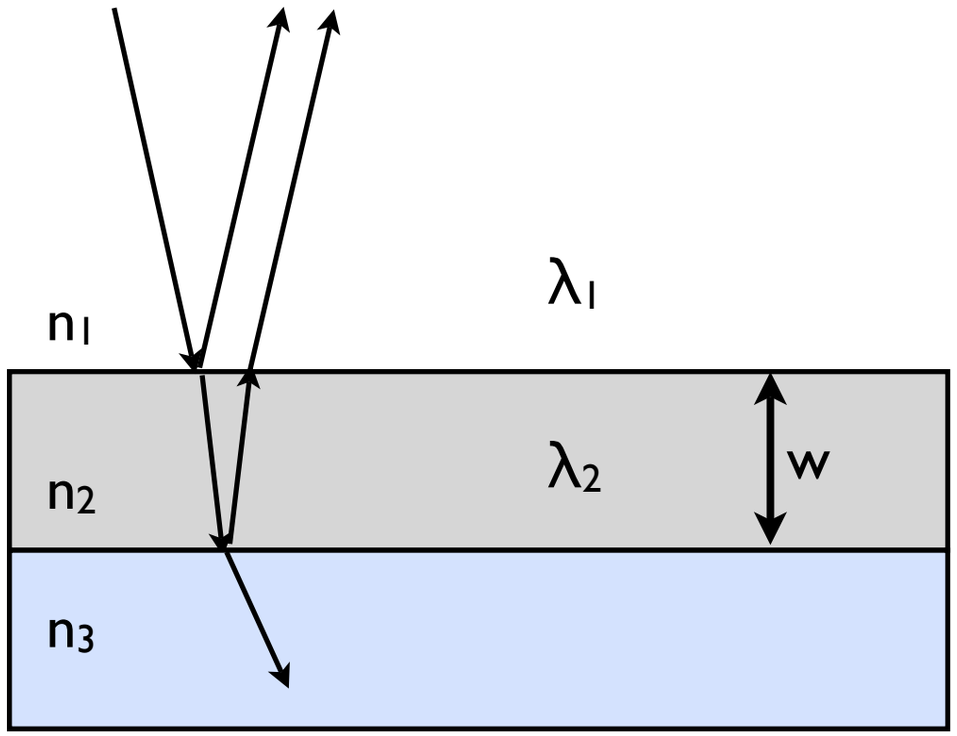
Top $\Delta\phi = \pi$ if $v_2 < v_1$

Bottom $\Delta\phi = \pi$ if $v_3 < v_2$

$$\delta_1 = \frac{\Delta\phi_{Tot}}{2\pi}\lambda_2$$

$$\delta_2 = 2w$$

Thin-film interference with light



Top Δϕ = π if $v_2 < v_1$

Bottom Δϕ = π if $v_3 < v_2$

$$\delta_1 = \frac{\Delta\phi_{Tot}}{2\pi}\lambda_2$$

$$\delta_2 = 2w$$

$$\delta_1 + \delta_2 = n\lambda_2 \longrightarrow \text{Max Reflection}$$

$$\delta_1 + \delta_2 = (n + 1/2)\lambda_2 \longrightarrow \text{Max Transmission}$$

$$f_1 = f_2 \longrightarrow \lambda_2 = \frac{n_1}{n_2}\lambda_1 = \frac{v_2}{v_1}\lambda_1$$

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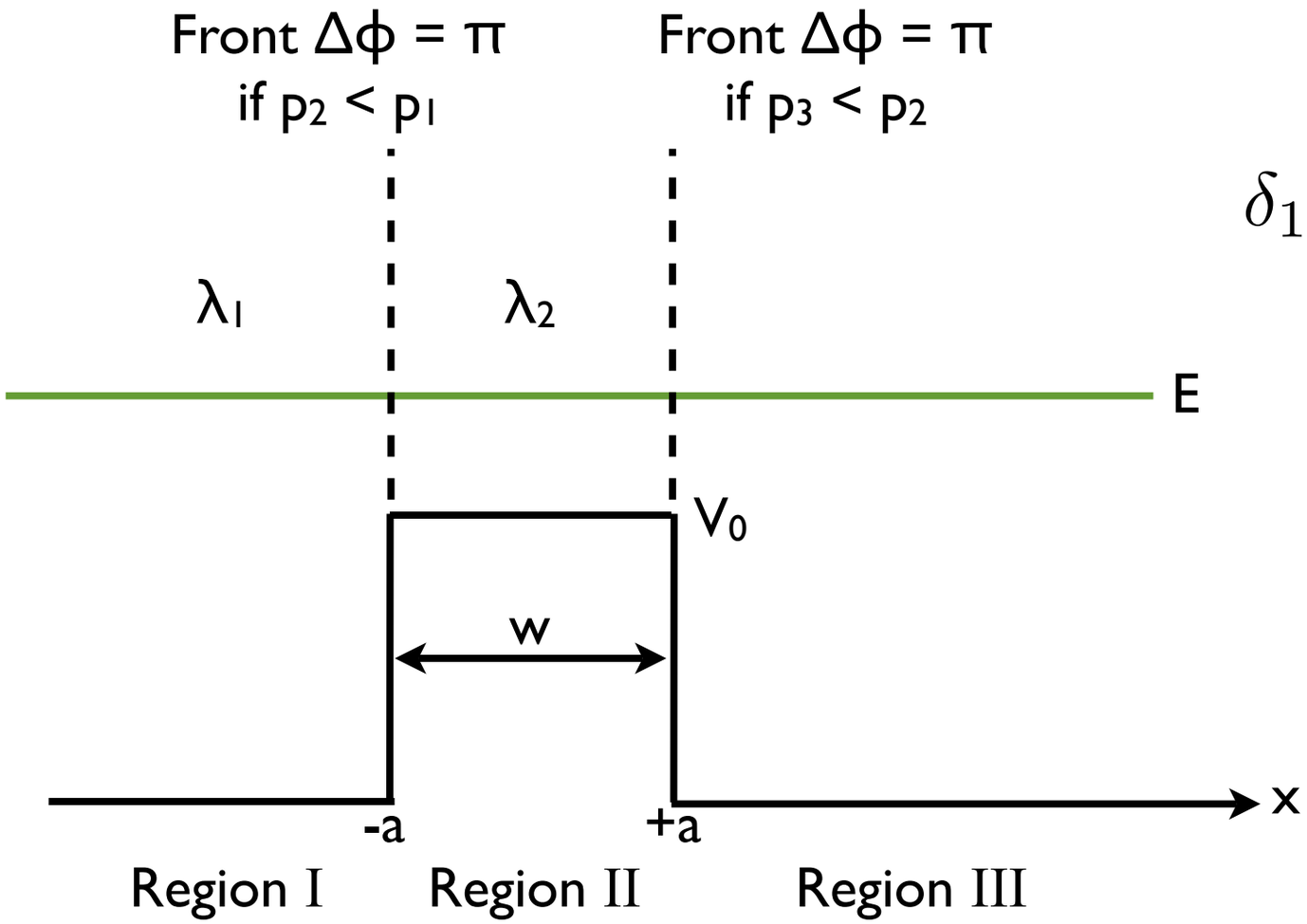
Thin-film barrier



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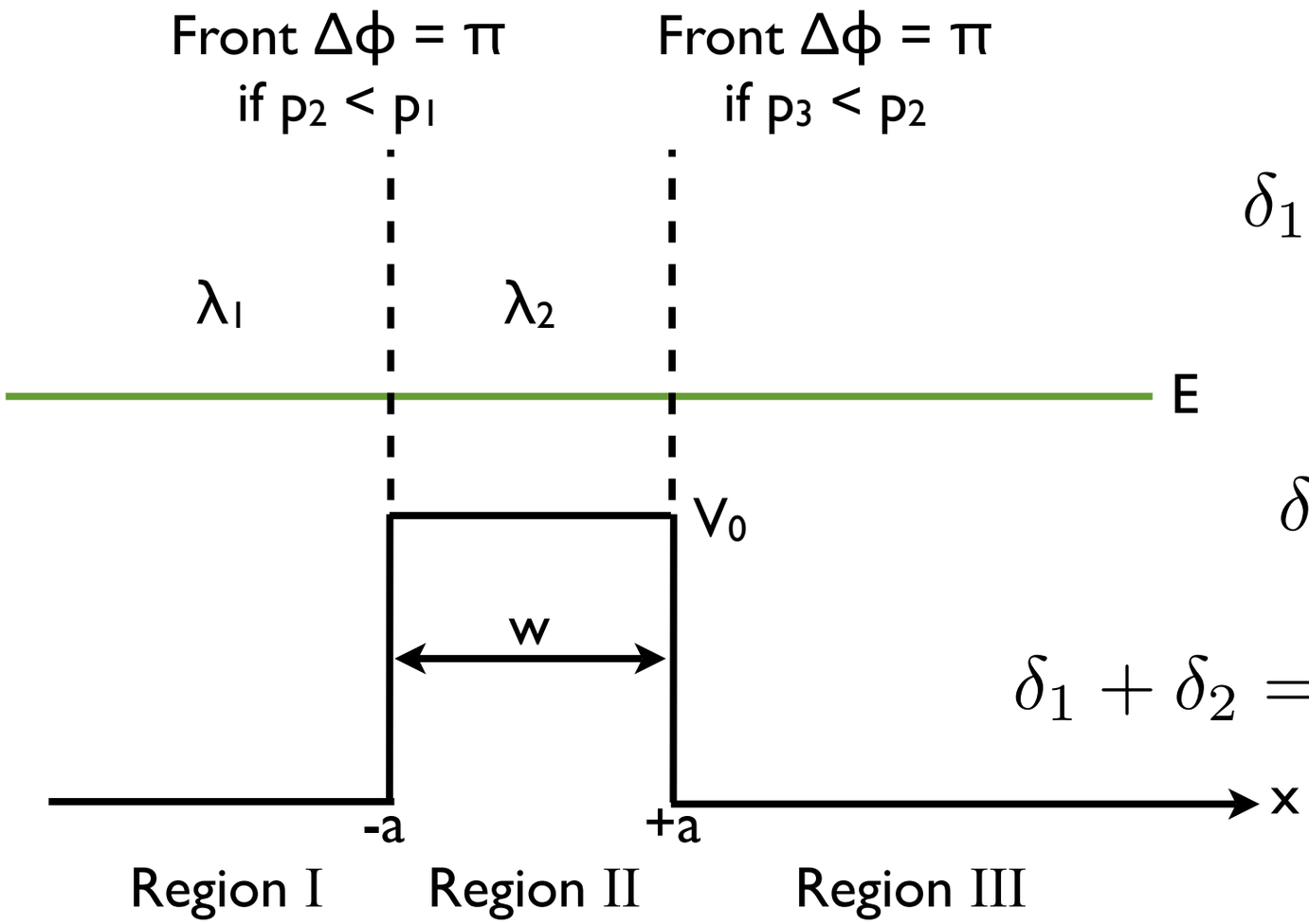
Thin-film barrier



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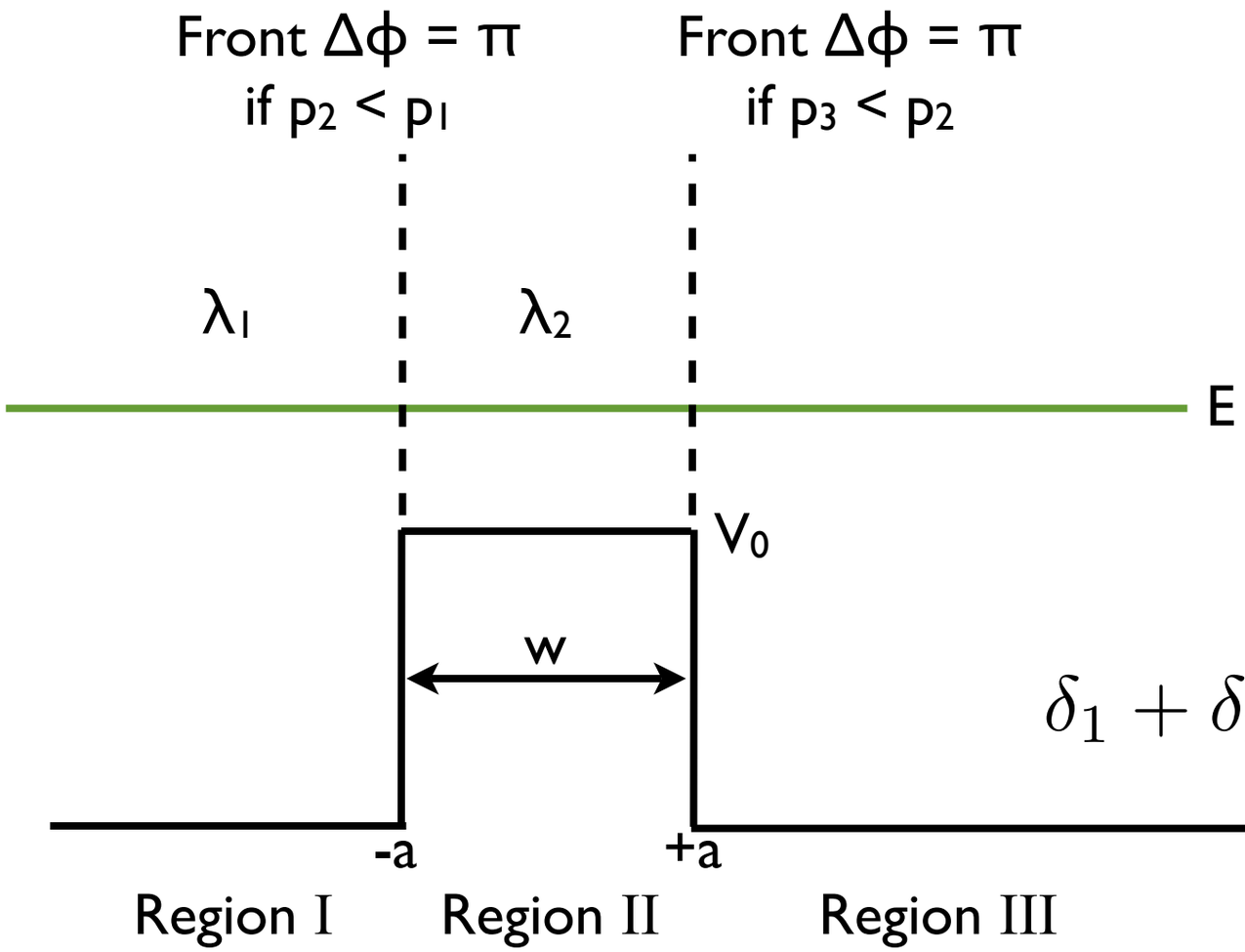
Thin-film barrier



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$$\delta_1 + \delta_2 = (n + 1/2)\lambda_2 \longrightarrow \text{Max Transmission}$$

$$\frac{p_1^2}{2m} = E \qquad \frac{p_2^2}{2m} = E - V_0$$

$$\longrightarrow \lambda_2 = \sqrt{\frac{E}{E - V_0}}\lambda_1$$

$$\lambda_1 = \frac{h}{p_1} \qquad \lambda_2 = \frac{h}{p_2}$$

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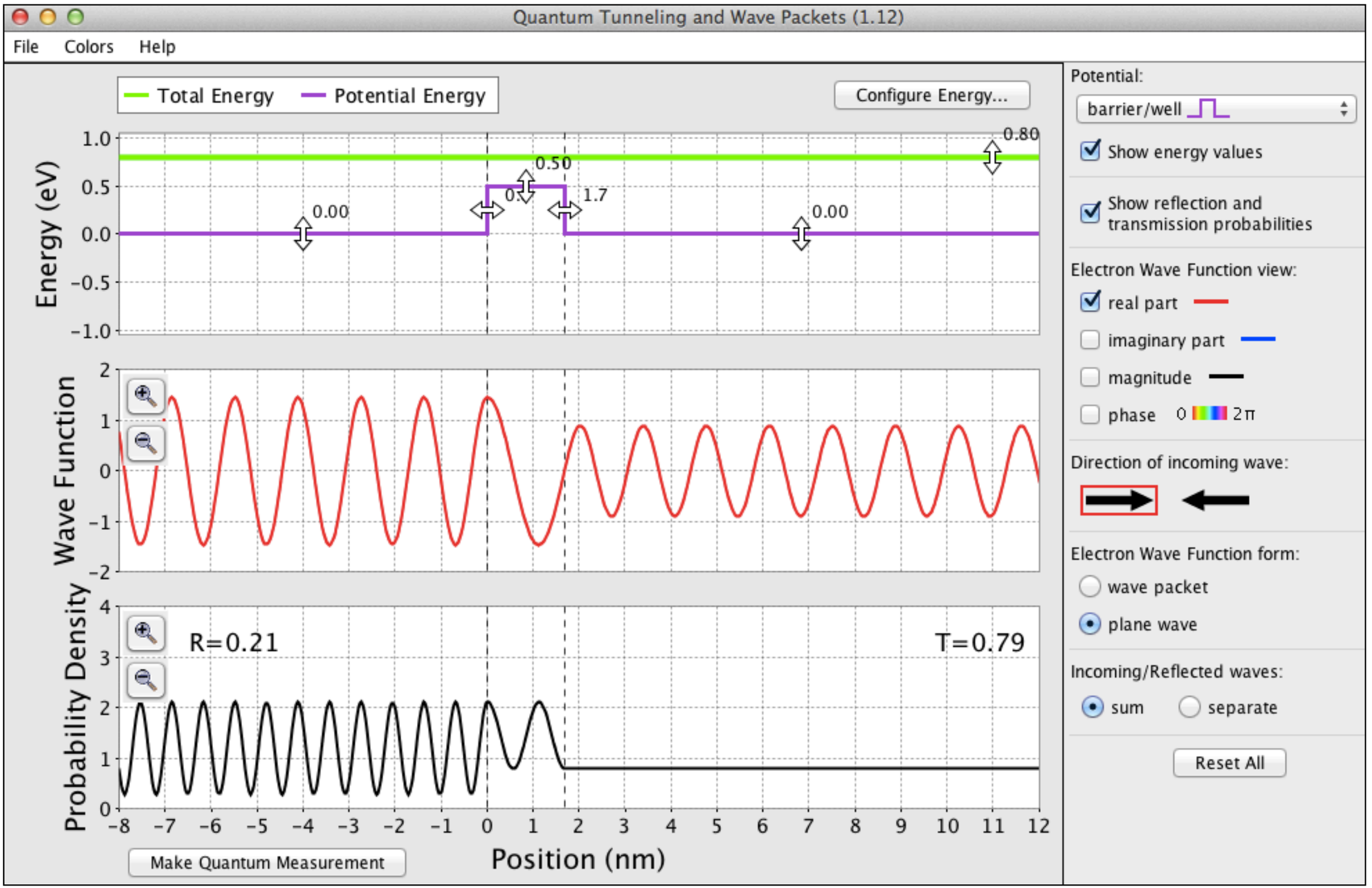

$\delta_1 = 0.5\lambda_2$

$\delta_2 = 1.5\lambda_2$

Max Reflection

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Building the analogy

- Thin-film problem where n_1 is not air
- Explore PhET simulation
- Map each step of thin-film calculation to barrier
- Check results with simulation
- Extensions
  - Produce two phase shifts
  - Make $\lambda_2 < \lambda_1$

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