

## Homework Set #4

\* **Problem 2.34** Consider the “step” potential:[53](#)

$$V(x) = \begin{cases} 0, & x \leq 0, \\ V_0, & x > 0. \end{cases}$$

- (a) Calculate the reflection coefficient, for the case  $E < V_0$ , and comment on the answer.
- (b) Calculate the reflection coefficient for the case  $E > V_0$ .

- (c) For a potential (such as this one) that does not go back to zero to the right of the barrier, the transmission coefficient is *not* simply  $|F|^2 / |A|^2$  (with  $A$  the incident amplitude and  $F$  the transmitted amplitude), because the transmitted wave travels at a different *speed*. Show that

$$T = \sqrt{\frac{E - V_0}{E}} \frac{|F|^2}{|A|^2}, \quad (2.175)$$

for  $E > V_0$ . *Hint:* You can figure it out using Equation [2.99](#), or—more elegantly, but less informatively—from the probability current (Problem [2.18](#)). What is  $T$ , for  $E < V_0$ ?

- (d) For  $E > V_0$ , calculate the transmission coefficient for the step potential, and check that  $T + R = 1$ .

Next page

**Problem 2.35** A particle of mass  $m$  and kinetic energy  $E > 0$  approaches an abrupt potential drop  $V_0$  (Figure 2.19).<sup>54</sup>

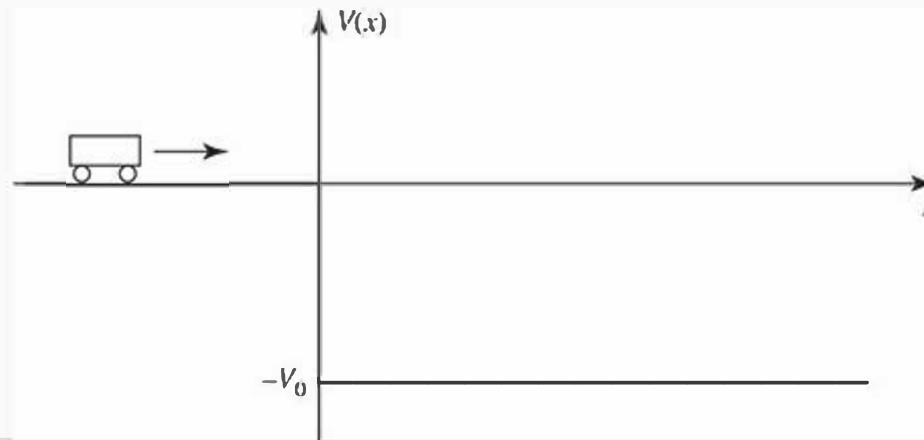


Figure 2.19: Scattering from a “cliff” (Problem 2.35).

- (a) What is the probability that it will “reflect” back, if  $E = V_0/3$ ? *Hint:* This is just like Problem 2.34, except that the step now goes *down*, instead of up.
- (b) I drew the figure so as to make you think of a car approaching a cliff, but obviously the probability of “bouncing back” from the edge of a cliff is *far* smaller than what you got in (a)—unless you’re Bugs Bunny. Explain why this potential does *not* correctly represent a cliff. *Hint:* In Figure 2.20 the potential energy of the car drops *discontinuously* to  $-V_0$ , as it passes  $x = 0$ ; would this be true for a falling car?
- (c) When a free neutron enters a nucleus, it experiences a sudden drop in potential energy, from  $V = 0$  outside to around  $-12$  MeV (million electron volts) inside. Suppose a neutron, emitted with kinetic energy 4 MeV by a fission event, strikes such a nucleus. What is the probability it will be absorbed, thereby initiating another fission? *Hint:* You calculated the probability of *reflection*

in part (a); use  $T = 1 - R$  to get the probability of transmission through the surface.