11.10 HINT: The low-energy limit is the same as the limit \( \kappa \to 0 \).

Note: \( \lim_{\kappa \to 0} \frac{1}{\kappa^3} \left[ \sin(\kappa a) - (\kappa a) \cos(\kappa a) \right] = \lim_{\kappa \to 0} \frac{1}{\kappa^3} \left[ (\kappa a) - \frac{(\kappa a)^3}{3!} - \cdots - (\kappa a) \left( 1 - \frac{(\kappa a)^2}{2!} + \cdots \right) \right] \)

11.12 HINT: When computing \( \sigma \), write \( \sin \theta = 2 \sin \frac{\theta}{2} \cos \frac{\theta}{2} \) in the numerator of the \( \theta \) integration. Make the following change of variables: \( u = 4k^2 \sin^2 \frac{\theta}{2} \Rightarrow du = 2k^2 \sin \frac{\theta}{2} \cos \frac{\theta}{2} d\theta \).

The integral and limits becomes \( \int_{0}^{4k^2} \frac{du}{(\mu^2 + u)^2} = -\frac{1}{\mu^2 + u} \bigg|_{0}^{4k^2} \).

11.13 HINT: In part (c), we must comparison in the 1st Born approximation, which assumes that the scattering is weak. In other words, \( f/a < 1 \), which is a measure of the strength of the scattered wave. This is the same as \( \beta < 1 \).

11.14 HINT: This is a classical trajectory problem again. To first approximation, you assume that the particle flies right on by along a straight path.

\[ \vec{F} = \frac{q_1 q_2}{4\pi \varepsilon_0 r^2} \hat{r} \Rightarrow \vec{F}_\perp = \frac{q_1 q_2}{4\pi \varepsilon_0 r} \cos \phi \] Note: \( \cos \phi = \frac{b}{r} \) and \( r = \sqrt{b^2 + x^2} \).

When computing the impulse momentum, you will want to write \( dt = dx/v \).

The following integral formula is handy: \( \int \frac{dx}{\left( b^2 + x^2 \right)^{3/2}} = \frac{x}{b^2 \sqrt{b^2 + x^2}} \)

You pretend that the impulse happens all at a point in the interaction region. This only makes sense if \( \theta \) is small. So looking from far away, we have \( \theta \sim I_\perp /mv \).