13.1 (a) Since $T = Q^2/2m = \frac{2p^2}{m}\sin^2\left(\frac{\theta}{2}\right) = \frac{2p^2}{m}\cdot\frac{1}{1+\cot^2(\theta/2)} = \frac{2p^2}{m}\cdot\frac{1}{1+(pvb/ze^2)^2}$

$$= \frac{2p^2}{m}\cdot\frac{z^2e^4/p^2v^2}{b^2+(ze^2/pv)^2}$$

define $b_{min}^{(c)} = ze^2/pv$, we have

$$T(b) = \frac{2z^2e^4}{mv^2}\,\frac{1}{b^2+(b_{min}^{(c)})^2}$$

For $b=0$, $T(0) = 2p^2/m = 2\gamma^2\beta^2mc^2$, since $p=\gamma m\beta c$.

(b) Assuming the heavy particle maintains a constant impact parameter, its transverse electric field is given by $E_2 = \frac{ze\gamma b}{(b^2+\gamma^2v^2t^2)^{3/2}}$. Then, the total transverse momentum transferred to the electron is

$$\Delta p = \int_{-\infty}^{+\infty} eE_2\,dt = 2ze^2\gamma b\int_0^{+\infty}\frac{dt}{(b^2+\gamma^2v^2t^2)^{3/2}} = \frac{2ze^2\gamma b}{\gamma^3v^3}\cdot\frac{\gamma^2v^2}{b^2}\cdot\frac{t}{\sqrt{t^2+(b/\gamma v)^2}}\Bigg|_0^{+\infty}$$

$$= \frac{2ze^2}{bv},$$

and the energy transfer is

$$T = (\Delta p)^2/2m = \frac{2z^2e^4}{mv^2b^2}.$$

In the result of part (a), for large impact parameter, $b \gg b_{min}^{(c)}$, we will asymptotically get the result here.