③

write $t = \tan\frac{\theta}{2}$

then $d\theta = \frac{2}{1+t^2}\,dt \qquad \cos\theta = \frac{1-t^2}{1+t^2}$

$$\frac{d\theta}{\cos^2\theta} = \frac{2\,dt}{1+t^2}\cdot\frac{(1+t^2)^2}{(1-t^2)^2} = \frac{2(1+t^2)}{(1-t^2)^2}dt$$

$$= \frac{1}{(1-t)^2}dt + \frac{1}{(1+t)^2}dt$$

$$\therefore \int\frac{d\theta}{\cos^2\theta} = -1 - \frac{1}{t-1} + 1 - \frac{1}{t+1} = -\frac{1}{t-1} - \frac{1}{t+1}$$

$$\therefore \int\frac{dv}{(1-v^2/c^2)^{3/2}} = c\cdot\frac{2t}{1-t^2} = c\,\frac{v/c}{\sqrt{1-v^2/c^2}} = \frac{v}{\sqrt{1-v^2/c^2}}$$

$$\therefore \frac{v}{\sqrt{1-v^2/c^2}} = \frac{qE}{m}t$$

$$\therefore v(t) = \frac{\frac{qE}{mc}t\cdot c}{\sqrt{1+\left(\frac{qE}{mc}t\right)^2}}$$

$$\therefore z = \int v\,dt'$$

$$= \int_0^t \frac{c\,\frac{qE}{mc}t'}{\sqrt{1+\left(\frac{qE}{mc}t'\right)^2}}\,dt'$$

$$= \frac{mc^2}{qE}\int_0^{\frac{qE}{mc}t}\frac{x\,dx}{\sqrt{1+x^2}} = \left(\sqrt{1+\left(\frac{qE}{mc}t\right)^2} - 1\right)\frac{mc^2}{qE}$$

$$\boxed{\therefore z = \frac{mc^2}{qE}\left(\sqrt{1+\left(\frac{qE}{mc}t\right)^2} - 1\right)}$$