Homework for Lecture 14, due Apr. 72014

1. Calculate the relative relation between $\Delta V / V, \Delta P / P$ and $\Delta E / E$. Note $V$ is the velocity of the particle, $P$ is the amplitude of the momentum and $E$ is the energy of the particle.
2. In class, we transform the longitudinal map

$$
\begin{aligned}
\delta_{n+1}-\delta_{n} & =\frac{e V}{\beta^{2} E_{0}}\left(\sin \phi_{n}-\sin \phi_{s}\right) \\
\phi_{n+1}-\phi_{n} & =2 \pi \eta \delta_{n+1}
\end{aligned}
$$

to longitudinal effective Hamiltonian. Actually we can also establish the one turn matrix for longitudinal motion if assume $\phi_{n}=\phi_{s}+\Delta_{n}$, where $\left|\Delta_{n}\right| \ll 1$. Find this matrix for $\left(\delta_{n+1}, \Delta_{n+1}\right)$ from $\left(\delta_{n}, \Delta_{n}\right)$. Find the tune for this map, by assuming the tune is very close to zero, which is true in ring accelerator.
3. For the example in class, find the synchrotron tune for both 100 GeV case and 15 GeV proton ring. The relative parameter is the cavity has 5 MV voltage, 360 harmonic. Compaction factor $\alpha_{c}=0.002$. The RF phase is zero or $\pi$. How does the number change if the same ring is for 3 GeV electron beam.

