

**Problems for:
ACCELERATOR PHYSICS AND
TECHNOLOGIES FOR LINEAR
COLLIDERS**

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Problem Set

1. Express the luminosity in a linear collider in terms of the disruption parameter, the beam power, center-of-mass energy, and vertical emittance.
2. Calculate the efficiency improvement in decreasing the repetition rate to 1 Hz in NLC and TESLA. What is the rf pulse length and the bunch train length and what could be the expected luminosity increase? What are the difficulties associated with such a change?
3. Derive an approximate expression for the luminosity loss due to the single bunch kink instability using perturbation theory. First, verify that the luminosity loss due to a rigid offset is $\Delta L/L = \exp(-\Delta^2/4\sigma^2)$ in the limit that $D \rightarrow 0$. Next, calculate the position offsets, in the limit that $\beta \gg \sigma z$, for a bunch with an initial position modulation of $y = y_0 \sin(\kappa z)$ which collides with a perfectly aligned beam. Describe the beam in terms of time and the longitudinal position within the bunch z . Assume a uniform longitudinal distribution between $\pm \sqrt{3}\sigma z$. Finally, use the $\Delta L/L$ expression from above to estimate the luminosity loss.
4. Derive an expression for the normalized emittance growth due to synchrotron radiation in a bunch compressor. Assume that dispersion function is closed (starts at zero and ends at zero) and use the formalism developed for a storage ring to calculate the growth rate – the damping term will be negligible.
5. Calculate the bunch length and energy spread after a simple bunch compressor consisting of an rf section followed by a magnetic chicane which generates a non-zero R_{56} . Calculate the rf voltage, as a function of the R_{56} , rf wavenumber, etc., for maximal compression.
6. Calculate the emittance growth in a linac due to wakefields from misaligned accelerator structures and dispersion from misaligned BPMs. Assume that the beam is steered to 'zero' the BPMs located at the focusing quadrupoles and the linac focusing FODO lattice has a 90 degree phase advance per cell and the beta functions and cell lengths increase as the square root of the beam energy. Further assume that the beam can be represented with simple two-particle models with one particle on-energy, at $z = +\sigma z$ and the other particle off-energy at $z = -\sigma z$. Start by calculating the $\Delta \epsilon$ for a single error and then sum along the linac.