2.1 The CLIC damping ring is designed for an energy of E=2.424 GeV. Take a bending radius of ρ=25 m and calculate the damping time for a simple ring with this radius without any wigglers.
The damping time in the CLIC design for a ring with wigglers is 2.6 ms. Calculate the total wiggler length L_w you need to reduce the damping time to this value, assuming a peak wiggler field of B=1.8 T and sinusoidal field distribution in the wiggler.

2.2 In the lecture, you have seen how you can shorten bunches with a magnetic chicane and an energy/time correlation. How can you increase the bunch length using a similar setup?

2.3 A damping ring at 2 GeV produces a bunch that is 5 mm long and has a relative energy spread of 0.1%. Assuming a compressor at a frequency of 1.3 GHz, estimate the RF voltage required to compress the bunch to 0.1 mm. What is the required R_{56}?
The final energy spread from this compressor would be 5% which is very large and will cause problems for chromatic emittance growth. One way around this is to use a two stage compressor, with some acceleration between the two to adiabatically damp the energy spread from the first compression before performing the second.
Perform the following steps:

a) Repeat the first compressor for a compression ratio of 10.

b) assuming the beam is then accelerated to 8 GeV, calculate the bunch compressor parameters for the final compression to 0.1 mm. What is the final energy spread? (For this example, you may assume the 6 GeV acceleration is on crest and is uniformly applied to the entire bunch).