1. *^7Li+^{208}Pb within a two-body cluster model.* We wish to study the reaction ^{7}Li+^{208}Pb at $E_{\rm lab}$=33 MeV within the coupled-channels method, using a cluster model of the ^{7}Li nucleus. We will consider only the bound state of this nucleus ($3/2^-$) and the first excited state (E_x = 0.477 MeV; $1/2^-$). These states will be described assuming a α+t cluster model. The nuclear part of the interaction between the clusters is parametrized in terms of a Gaussian potential with $V_0 = -87.77$ MeV and $R_0 = 2.52$ fm (absolute radius) and a spin-orbit part, also of Gaussian shape, with parameters $V_{so} = 3.8$ MeV and R_{so}=2.52 fm. The α+^{208}Pb and t+^{208}Pb interactions are described in terms of standard (volume) Woods-Saxon forms, with the following parameters ($R_x = r_x A_t^{1/3}$):

System	V_0 (MeV)	r_0 (fm)	a_0 (fm)	W_v (MeV)	r_i (fm)	a_i (fm)	r_c (fm)
α+^{208}Pb	35.0	1.547	0.570	9.0	1.547	0.57	1.547
t+^{208}Pb	161.24	1.20	0.720	18.06	1.40	0.84	1.30

Questions:

   (a) Calculate the elastic and inelastic scattering angular distributions. Check the convergence of the calculation with respect the the maximum integration radius (`rmatch`) and the maximum total angular momentum (`jtmax`).

   (b) Compare the *converged* calculation with the elastic and inelastic data reported in the work of Rusek *et al*, Nuclear Physics A 614 (1997) 112.

   (c) Reduce the maximum total angular momentum to `jtmax=25` and recalculate the inelastic angular distribution. How would you interpret the observed oscillations?

   (d) Using the information contained in the `fort.56` output file, plot the reaction and inelastic cross section as a function of the total angular momentum. Comment on the results in connection with the previous item.

2. *CDCC calculation for deuteron scattering.* Consider the reaction d+^{58}Ni at $E_d = 80$ MeV, described in a three-body model (p+n+^{58}Ni). The proton-neutron interaction is described with a simple Gaussian potential: $V(r) = -72.15\ \exp[-(r/1.484)^2]$ MeV.

   (a) Find suitable potentials for the proton-^{58}Ni and neutron-^{58}Ni systems at the appropriate energy per nucleon (you may get them from `http://www-nds.iaea.org/RIPL-3/`).

   (b) With the help of the CDC code, build the FRESCO input for this reaction. Consider only the partial waves ℓ=0,2 for the deuteron continuum, and set to zero the spin of the proton and the neutron. For each partial wave, truncate the continuum at a maximum energy of E_{rel}=20 MeV and discretize it using initially 5 bins with the same width (in k). Calculate the elastic scattering (relative to Rutherford) and the (angle-integrated) breakup differential cross section with respect to the excitation energy ($d\sigma/dE_x$). For the latter, you may use the code SUMXEN installed in the TALENT server.

(c) Increase progressively the maximum excitation energy and number of bins until you get converged (i.e. stable) results for both the elastic and $d\sigma/dE_x$ breakup cross sections.

(d) Compare with the elastic data for this reaction (available at the TALENT website).

(e) Remove the continuum states, and perform a calculation including *only* the ground state of the deuteron. Compare the result with the data and the with full calculation.

(f) Repeat the calculation using the DWBA approximation (`iter=1`, `iblock=0`) and compare with the result of the previous item. What can we conclude regarding the influence of multi-step processes in this reaction?

(g) Perform a new calculation at $E_d = 21$ MeV. Study the convergence with respect the the number of bins and the maximum excitation energy (for simplicity, use the same proton and neutron potentials as in the previous case).

(h) Obtain the breakup energy distribution ($d\sigma/dE_x$) and compare with the results at E_d=80 MeV. Interpret the results.

(i) At this energy, compare the full CC calculation with the DWBA solution. Interpret the results.