1. *Electric properties of ^{10}Be from HF densities.* In a simple collective model, one may assume that the transition density is related to the derivative of the central density according to,

$$\langle I_f \| \rho_\lambda^{(p,n)} \| I_i \rangle \simeq \langle I_f \| \delta_\lambda^{(p,n)} \| I_i \rangle \frac{d\rho_0^{(p,n)}}{dr}$$

   (a) Using the code `dens` with the Sk20 interaction, generate the HF proton density for the ground state of the ^{10}Be nucleus ($\rho_0^{(p)}$). Calculate the rms of this nucleus.

   (b) Estimate the value of $\langle I_f \| \delta_\lambda^{(p,n)} \| I_i \rangle$ using the electric transition probability between the ground state (0^+) and the first excited state (2^+), $B(E2; 0^+ \to 2^+) = 30$ e^{2}fm^4.

   (c) Compare the result with the value deduced from the rotor model, assuming an *intrinsic* deformation parameter of β_2=0.67.

2. *Coupled-channels analysis of ^7Li+^{208}Pb with a collective rotational model.* We plan to study the elastic and inelastic scattering of ^{7}Li on ^{208}Pb at E_{lab}=33 MeV within a coupled-channels method, including the ground state ($3/2^-$) and first excited state ($1/2^-$) of ^{7}Li, assuming that these two states are members of a $K = 1/2$ rotational band. Consider Coulomb quadrupole couplings using the (intrinsic) reduced matrix element $M_n(E2) =$ 5.06 e fm^2. For the nuclear excitation, use the (intrinsic) *deformation parameters* $\beta_2^{(r)} =$ 0.160 fm and $\beta_2^{(i)} = 0.187$ fm, for the real and imaginary parts, respectively.

   For the real and imaginary parts of the central interaction between ^{7}Li and ^{208}Pb, consider a standard Woods-Saxon potential with the parameters of the table below ($R_x = r_x(7^{1/3} + 208^{1/3})$).

System	V_0 (MeV)	r_0 (fm)	a_0 (fm)	W_v (MeV)	r_i (fm)	a_i (fm)	r_c (fm)
^{7}Li+^{208}Pb	15.4	1.3	0.65	13.2	1.3	0.65	0.983

   Questions:

   (a) Calculate the elastic and inelastic angular distributions. Compare your results with the data from NPA614, 112 (1997).

   (b) Calculate the inelastic angular distribution, switching off the nuclear deformation ($\beta_2 = 0$). Repeat the calculation including the nuclear deformation, but removing the Coulomb quadrupole couplings $M_n = 0$. Compare the results with the full calculation (i.e. including both kinds of couplings simultaneously) and interpret the results.

   (c) Using the value of $M_n(E2)$, derive the values of $B(E2; 3/2^- \to 1/2^-)$ and Q (quadrupole moment). Compare with the experimental values: $B(E2; 3/2^- \to 1/2^-) = 8.3 \pm 0.5$ e^{2}fm^4 and $Q = -4.0$ e fm^2. In view of these results, what can we conclude regarding the validity of the rotational model?

3. *Collective model with general matrix elements.* Consider the reaction ^{16}O+^{64}Zn at $E_{c.m.}$=32, 35.2 and 51.2 MeV, reported by Tenreiro *et al* [Phys Rev C53 (1996) 2870]. We want to study the inelastic channel corresponding to the excitation of the first excited state in ^{64}Zn (E_x=0.992 MeV, 2^+), using the coupled-channels formalism and the *collective model*. For the central part of the ^{16}O+^{64}Zn potential, use the depths listed in Table IV (depths) and I (radii, diffuseness) of the referred paper. For the Coulomb excitation, we will consider the experimental value of the electric transition probability $B(E2; 0^+ \to 2^+)$=1680 e^2fm^4. The nuclear transition potential is obtained from the *derivative* of the central potential, multiplied by the reduced matrix elements of the deformation length operator (dot *not* assume the rotational model). For the latter, use the values listed in Table IV of the referred paper ($\beta R \equiv \langle 2^+ \| \hat{\delta}_2 \| 0^+ \rangle$ according to our notation).

   Questions:

   (a) Estimate the height of the Coulomb barrier for this system.

   (b) Calculate the elastic and inelastic scattering angular distributions, and compare with the data from Tenreiro *et al* (these data can be obtained from the EXFOR database: `http://www.nndc.bnl.gov/exfor`).

   (c) Consider separately the effect of the nuclear and Coulomb excitation and compare the results with the full calculation (i.e. including both kinds of couplings simultaneously). Interpret the results.

   (d) Repeat the calculation using the DWBA approximation (`ITER=1`, `IBLOCK=0`) and see how the elastic and inelastic angular distribution changes, in comparison with the full CC calculation. In view of these results, what can we conclude about the importance of multi-step couplings?