1. **STRIPS Domain Engineering:** We want to plan actions for a vacuum cleaner: There is a house with three rooms: A hallway, a bedroom and a living room, where there are doors between the hallway and the bedroom and between the hallway and the living room, but no doors between the bedroom and the living room. There may be dirt in one or more of these rooms, which the vacuum cleaner can remove. However, the vacuum cleaner also has a limited capacity of one dirt unit, which can only be removed by putting it into the trash can in the hallway. Define STRIPS planning operators for moving between rooms, removing dirt, and emptying the vacuum cleaner.

2. **STRIPS Domains:** Given the operator for putting a block on top of another on slide 16, first describe it as a STRIPS operator, and then list which actions it would expand to, assuming we have blocks A, B, and C.

3. **STRIPS Planning:** Given an initial state of $\{\text{free}(), \text{on}(A, \mathit{Table}), \text{on}(B, A), \text{clear}(B), \text{on}(C, \mathit{Table}), \text{clear}(C)\}$ for our blocks world, with operators `pickup` and `put` (slides 15 and 16), which actions are applicable in the initial state, and which successor states would each of them result in?

4. **STRIPS Planning:** Given an initial state of $\{\text{free}(), \text{on}(A, \mathit{Table}), \text{on}(B, A), \text{on}(C, B)\}$ for our blocks world, with operators `pickup` and `put` (slides 15 and 16), can you find a plan to satisfy the goal $\{\text{on}(B, \mathit{Table}), \text{on}(C, \mathit{Table}), \text{on}(A, B)\}$? If you can't, add (reasonable) additional operators until you can.

5. **STRIPS Planning:** Given an initial state of $\{\text{alive}(\mathit{IndianaJones}), \text{alive}(\mathit{NaziSoldiers}), \text{alive}(\mathit{USArmy}), \text{buried}(\mathit{Ark})\}$, and a goal of $\{\text{dead}(\mathit{NaziSoldiers}), \text{has}(\mathit{USArmy}, \mathit{Ark})\}$, corresponding to the plot of *Indiana Jones and the Raiders of the Lost Ark*, and the following four operators:

Name: `dig`
Variables: P, Q
Positive Preconditions: $\{\text{alive}(P), \text{buried}(Q)\}$
Negative Preconditions: None
Add List: $\{\text{has}(P, Q)\}$
Delete List: $\{\text{buried}(Q)\}$

Name: `open`
Variables: P
Positive Preconditions: $\{\text{alive}(P), \text{has}(P, \mathit{Ark})\}$
Negative Preconditions: None
Add List: $\{\text{dead}(P)\}$
Delete List: $\{\text{alive}(P)\}$

Name: `give`
Variables: P, Q, I
Positive Preconditions: $\{\text{alive}(P), \text{alive}(Q), \text{has}(P, I)\}$
Negative Preconditions: None
Add List: $\{\text{has}(Q, I)\}$
Delete List: $\{\text{has}(P, I)\}$

Name: `steal`
Variables: P, Q, I
Positive Preconditions: $\{\text{alive}(P), \text{dead}(Q), \text{has}(Q, I)\}$
Negative Preconditions: None
Add List: $\{\text{has}(P, I)\}$
Delete List: $\{\text{has}(Q, I)\}$

Find at least two different plans that achieve the goal. Do these plans correspond to the story of the movie? Why/why not?

6*. **Bonus points:** Show that propositional STRIPS planning is PSPACE-hard even if **all actions except for one** are restricted to five preconditions and **all** actions have at most one effect. (Hint: The proof of theorem 3.3. in *The Computational Complexity of Propositional Strips Planning* is a good start, but note that it adds one action with a large number of precondition for every state transition in the Turing Machine. You will have to figure out a way to reduce that to one such action overall.)