1. Suppose that \( A \) and \( B \) are entity types having (at some moment in time) associated entity sets \{a_1, a_2, a_3, a_4\} and \{b_1, b_2, b_3\}, respectively. Suppose also that there exist binary relation-ship types \( R_1 \) through \( R_6 \) involving \( A \) and \( B \). The corresponding relationship sets (at the same moment in time) are given in parts (a) through (f). For each one, you are to indicate the strongest cardinality ratio constraint and the strongest participation constraint (with respect to each of \( A \) and \( B \)) with which it is consistent (i.e., that it does not violate). For each problem, then, your answer should be a member of the set
\[
\{1:1, 1:N, N:1, M:N\} \times \{\text{total, partial}\} \times \{\text{total, partial}\}
\]
For example, the answer (1:N, total, partial) would indicate that

1. the given relationship set satisfied the 1:N cardinality ratio constraint but not the (stronger) 1:1 constraint,
2. participation of \( A \) was consistent with the total participation constraint, and
3. participation of \( B \) was consistent with the partial participation constraint (which is really no constraint at all) but not with the (stronger) total participation constraint.

(a) Relationship set of \( R_1 \): \{(a_2,b_2),(a_3,b_3),(a_1,b_1)\}
(b) Relationship set of \( R_2 \): \{(a_2,b_3),(a_3,b_3),(a_4,b_2),(a_1,b_3)\}
(c) Relationship set of \( R_3 \): \{(a_1,b_2),(a_1,b_1)\}
(d) Relationship set of \( R_4 \): \{(a_3,b_2),(a_3,b_1),(a_3,b_3),(a_4,b_3),(a_4,b_1)\}
(e) Relationship set of \( R_5 \): \{(a_2,b_2),(a_2,b_1),(a_3,b_1)\}
(f) Relationship set of \( R_6 \): \{empty set\}

2. Devise a relationship set (for a binary relationship type involving \( A \) and \( B \), exactly as above) for which the correct answer (to the question repeatedly posed in the problem above) is (N:1, total, total).

3. The set of possible answers for each of parts (a) through (f) of problem 1 has sixteen elements (4 · 2 · 2, corresponding to the product of the number of choices for each component). Five of the sixteen are impossible, given our choice of entity sets, namely \{a_1, a_2, a_3, a_4\} for \( A \) and \{b_1, b_2, b_3\} for \( B \). Identify three of the impossible answers and, for each one, tell why it is impossible.
4. Design an ER schema diagram like that in Figure 7.2 of Elmasri & Navathe (6th edition) for the following set of requirements pertaining to a UNIVERSITY database application.

Each student:

- has a Royal Number that uniquely identifies her/him
- has a name composed of a first name and last name
- has one or more majors
- is/was enrolled in zero or more course sections, and for each such section that is finished, earned a grade

Each department:

- has a unique name
- has faculty members who work for it, one of whom assumed, on some date, the position of department chair
- controls a set of (zero or more) courses
- offers (has offered) sections of (zero or more of the) courses it controls

Each major:

- is affiliated with a particular department
- has a name that, in combination with the affiliated department, uniquely identifies it
- has (zero or more) students pursuing it

Each course:

- is controlled by some department
- has a number, which, in combination with the department that controls it, uniquely identifies it
- has a name
- is worth a certain number of credit hours
- has zero or more prerequisite courses, none of which is itself
- is a prerequisite for zero or more courses
Each course section:

- is/was an offering of some course during some semester
- has a section number that, in combination with the items listed above (course and semester), uniquely identifies it
- is/was taught by some faculty member
- is/was populated by students, each of whom is taking/took it with a “grade mode” of either pass/fail, normal, or audit.

Each faculty member:

- has a unique ID
- works for one or more departments
- is teaching/taught sections of courses

Make sure to indicate (using the diagrammatic conventions shown in Figure 7.14 and used in Figure 7.2)

- which are the strong and which are the weak entity types
- key attribute(s) of each strong entity type
- partial key attribute(s) of each weak entity type
- which are the regular and which are the identifying relationship types
- for each relationship type, to which constraints (of the cardinality ratio and participation varieties) it must conform

Note any assumptions you made to fill in missing requirements or to clarify existing ones. Note any (conditions specified within the) requirements that you could not figure out how to express within the ER schema.