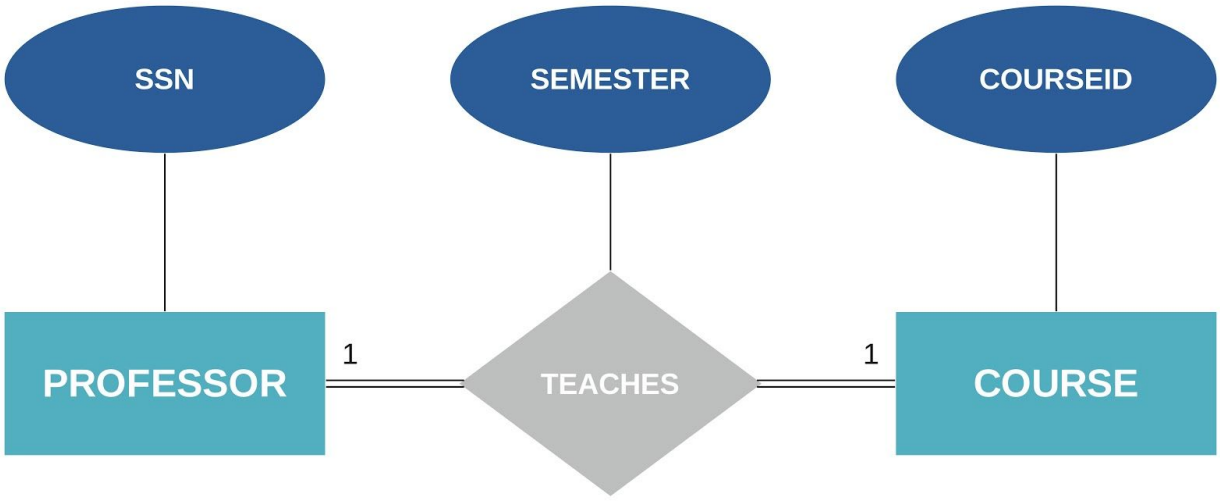
1. **Exercise 2.2** A university database contains information about professors (identified by social security number, or SSN) and courses (identified by courseid). Professors teach courses; each of the following situations concerns the Teaches relationship set. For each situation, draw an ER diagram that describes it (assuming no further constraints hold).
   - (1) Professors can teach the same course in several semesters, and each offering must be recorded.
   - (3) Every professor must teach some course.
   - (4) Every professor teaches exactly one course (no more, no less).
   - (5) Every professor teaches exactly one course (no more, no less), and every course must be taught by some professor.



2. **Exercise 19.7** Suppose you are given a relation R with four attributes A, B, C, and D. For each of the following sets of FDs, assuming those are the only dependencies that hold for R, do the following: (a) Identify the candidate key(s) for R. (b) Identify the best normal form that R satisfies (1NF, 2NF, 3NF, or BCNF).

   1. C → D
      C → A
      B → C

L	L+R	R
B	C	A, D

$\{B\}^+ = \{B, C, D, A\}$ ✓

   a. Candidate Keys: B
   b. Best Normal Form: 2nd Normal Form (3rd Normal Form violated by first rule [C → D] since C is not a super key and D is non-prime).

2. B → C
   D → A

L	L+R	R
B, D		A, C

$\{BD\}^+ = \{B, D, C, A\}$ ✓

   a. Candidate Keys: BD
   b. Best Normal Form: 1st Normal Form (2nd Normal Form violated by both rules since C and A are non-prime but depend on subset of candidate key).

3. ABC → D
   D → A

L	L+R	R
B, C	A, D	

$\{BC\}^+ = \{B, C\}$ ✗
$\{BCA\}^+ = \{B, C, A, D\}$ ✓
$\{BCD\}^+ = \{B, C, D, A\}$ ✓

   a. Candidate Keys: BCA, BCD
   b. Best Normal Form: 3rd Normal Form (Boyce-Codd Normal Form violated by second rule [D → A] since D is not a super key).

4. A → B
   BC → D
   A → C

L	L+R	R
A	B, C	D

$\{A\}^+ = \{A, B, C, D\}$ ✓

   a. Candidate Keys: A
   b. Best Normal Form: 2nd Normal Form (3rd Normal Form violated by second rule [BC → D] since BC is not a super key and D is non-prime).

5. AB → C
   AB → D
   C → A
   D → B

L	L+R	R
	A, B, C, D	

$\{A\}^+ = \{A\}$ ✗
$\{B\}^+ = \{B\}$ ✗
$\{C\}^+ = \{C, A\}$ ✗
$\{D\}^+ = \{D, B\}$ ✗
$\{AB\}^+ = \{A, B, C, D\}$ ✓
$\{AC\}^+ = \{A, C\}$ ✗
$\{AD\}^+ = \{A, D, B, C\}$ ✓
$\{BC\}^+ = \{B, C, A, D\}$ ✓
$\{BD\}^+ = \{B, D\}$ ✗
$\{CD\}^+ = \{C, D, A, B\}$ ✓

a. Candidate Keys: AB, AD, BC, CD
b. Best Normal Form: 3rd Normal Form (Boyce-Codd Normal Form violated by third and fourth rules since C and A are not super keys).

3. Consider the following set of functional dependencies on the relational schema R (A, B, C, D, E, F):

   A → BCD
   BC → DE
   B → D
   D → A

   a. Compute $\{B\}^+$.

      $\{B\}^+ = \{B, D, A, C, E\}$

   b. Find all the candidate keys of this relation.

L	**L+R**	**R**
F	A, B, C, D	E

$\{FA\}^+ = \{F, A, B, C, D, E\}$ ✓
$\{FB\}^+ = \{F, B, D, A, C, E\}$ ✓
$\{FC\}^+ = \{F, C\}$ ✗
$\{FD\}^+ = \{F, D, A, B, C, E\}$ ✓

Candidate Keys: FA, FB, and FD

   c. Is the schema in Boyce-Codd Normal Form? Explain your answer.

      No, this schema is not in Boyce-Codd Normal Form. None of the attributes depend on a super key, since none of the attributes on the left include 'F', which is a part of the candidate key.

   d. Is the schema in 3rd Normal Form? Explain your answer.

      No, this schema is not in the 3rd Normal Form. In the first rule (A → BCD), 'A' is not a super key, and BCD has a non-prime attribute 'C'.

   e. Is the schema in 2nd Normal Form? Explain your answer.

      No, this schema is not in the 2nd Normal Form. In the first rule (A → BCD), 'A' is not a whole candidate key and yet 'C' – a non-prime attribute – depends on it.