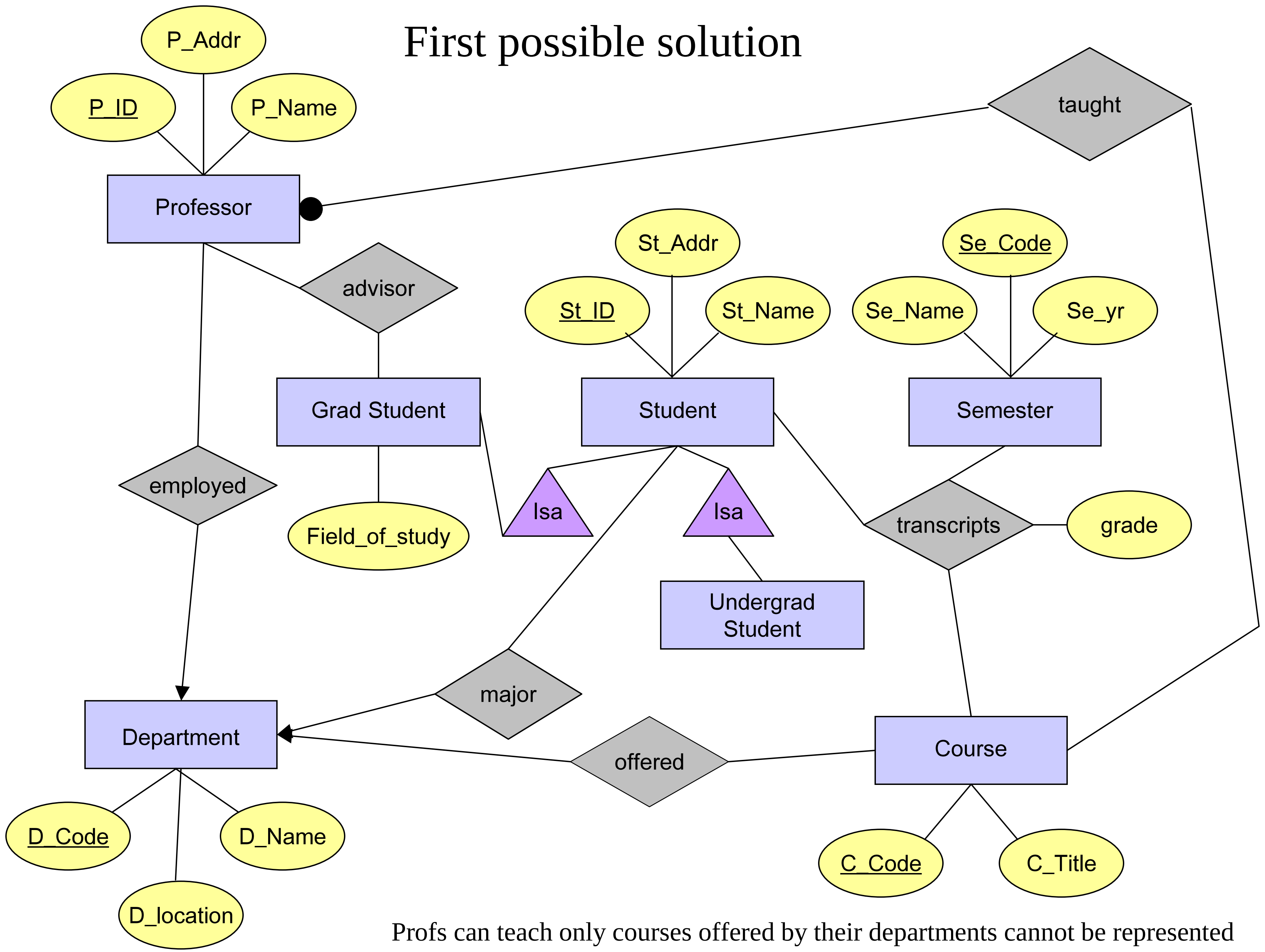
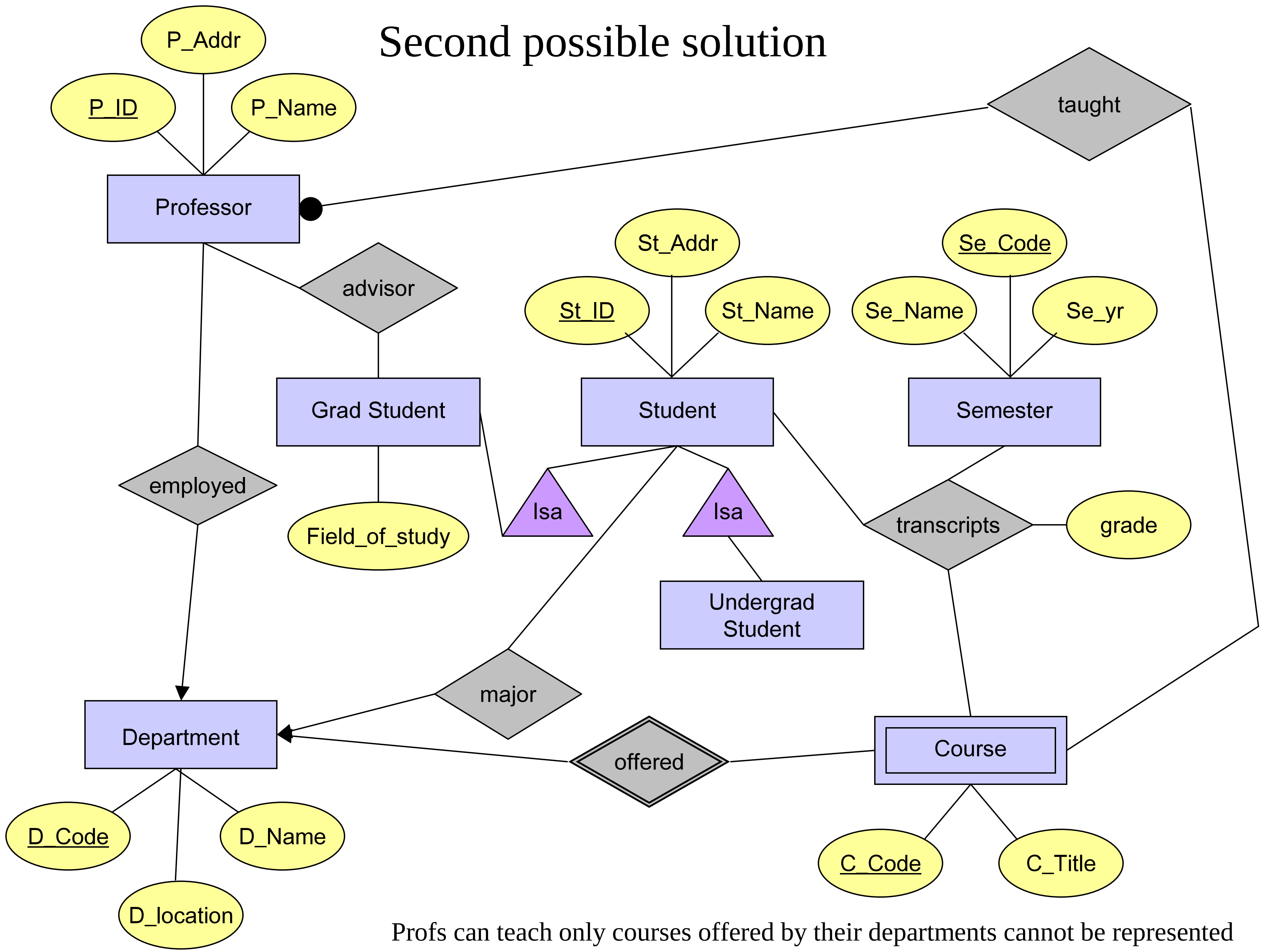
First possible solution



Profs can teach only courses offered by their departments cannot be represented

Second possible solution



Profs can teach only courses offered by their departments cannot be represented

Grade

- Undergraduate
  - 5 entities each 3 (missing/wrong key -1)
  - 6 relationships each 3 (correct connection, multiplicity, arrows)
  - Undergraduate 3
  - Graduate 4 (relation, field of study)
- Graduate
  - 5 entities (student 3, profs 3, other 2)
  - 6 relationships each 3 (correct connection, multiplicity, arrows)
  - Undergraduate 2
  - Graduate 2 (relation, field of study)

The simple way of converting E/R to relational design

- The five “main” entity sets:
  - Professors(ID,Address,Name)
  - Students(ID,Address,Name)
  - Courses(ID,Title) or Courses(CID,DID,Title)
  - Departments(ID,Location,Name)
  - Semesters(Code,Year,Name)
- The two ISA subclasses:
  - Undergraduate(StudentID)
  - Graduate(StudentID,FieldOfStudy)
- The relationships:
  - Empoyed(ProfID,DepartmentID)
  - Major(StudentID,DepartmentID)
  - Offerred(DepartmentID,CouseID) or none
  - Advisor(ProfID,GradStudentID)
  - Teach(ProfID,CourseID) or Teach(ProfID,CourseID,DepID)
  - Transcripts(StudID,SemesterCode,CourseID,Grade) or Transcripts(StudID,SemesterCode,CourseID,DepCode,Grade)

A better way of converting E/R to relational design

- The five “main” entity sets:
  - Professors(ID,Address,Name) [Add DepartmentID, Remove the Empoyed relationship – Slide 16/ch3]
  - Students(ID,Address,Name) [Add DepID, Remove Major]
  - Courses(ID,Title) or Courses(CID,DID,Title) [Use the second one, remove offerred relationship]
  - Departments(ID,Location,Name)
  - Semesters(Code,Year,Name)
- The two ISA subclasses:
  - Undergraduate(StudentID) [could be removed but not a good idea]
  - Graduate(StudentID,FieldOfStudy)
- The relationships:
  - Empoyed(ProfID,DepartmentID) or none
  - Major(StudentID,DepartmentID) or none
  - Offerred(DepartmentID,CouseID) or none
  - Advisor(ProfID,GradStudentID)
  - Teach(ProfID,CourseID) or Teach(ProfID,CourseID,DepID)
  - Transcripts(StudID,SemesterCode,CourseID,Grade) or Transcripts(StudID,SemesterCode,CourseID,DepCode,Grade)

Grade

- All
  - 5 relations corresponding to 5 entity sets each 2
  - Transcripts 2
  - Teach 2
  - Undergraduate 1
  - Graduate 1
  - Major 1
  - Offer 1
  - Employed 1
  - Advisor 1
- Missing key, no justification each -0.5

(20/15) Given a relation R(A,B,C,D,E) with the following functional dependencies: AB$\longrightarrow$E, AC $\longrightarrow$ D, BC $\longrightarrow$ D, D $\longrightarrow$ A, and E $\longrightarrow$ B. What are the nontrivial functional dependencies of the relation S(A,B,C) that is obtained from R by projecting out the two attributes D and E.

To answer the question, we need the following computation:

$\{\}^+ = \{\}$

$\{A\}^+ = \{A\}$

$\{B\}^+ = \{B\}$

$\{C\}^+ = \{C\}$

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

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

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

This implies that the nontrivial functional dependencies of S(A,B,C) come only from the last computation, i.e., $\{B,C\}^+ = \{B,C,D,A,E\}$. So, we have:

BC $\rightarrow$ A, BC $\rightarrow$ AB, BC $\rightarrow$ AC, BC $\rightarrow$ ABC are the nontrivial FDs of S.

The first FD is enough since the other are trivially derived from it.

GRADE: correctly compute each of the above 2.5/2, identifying BC $\rightarrow$ A 2.5/1, wrong answer -1 each

(15/15) Given the relation R(A,B,C,D) with the following instance:

A	B	C	D
1	2	3	4
1	2	3	5
2	2	3	4
4	2	3	6
1	2	3	9

Will the following functional dependencies hold? Justify your answer.

ABCD $\rightarrow$ BD YES – because this is a trivial FD 4pt

ABC $\rightarrow$ D NO – because the first two rows have same ABC but different D 3pt

BC $\rightarrow$ D NO – because the first two rows have same BC but different D 3pt

What are the possible, nontrivial functional dependencies of the relation? (limit yourself on functional dependencies whose right hand side has only one attribute). Justify your answer.

There are several possible nontrivial FD. If you list 5 of them (each one point), it is enough. Some of them are

B $\rightarrow$ C : because whenever B is the same so is C (there is no violation to this FD from the instance)

C $\rightarrow$ B : because whenever C is the same so is B (..)

AB $\rightarrow$ C : because whenever AB is the same so is C (..)

A $\rightarrow$ B : because whenever A is the same so is B (..) [but not B $\rightarrow$ A]

A $\rightarrow$ C : because whenever A is the same so is C (..) [but not C $\rightarrow$ A]

D $\rightarrow$ C : because whenever D is the same so is C (..) [but not C $\rightarrow$ D]

D $\rightarrow$ B : because whenever A is the same so is C (..) [but not B $\rightarrow$ D]

From these, you can list several derived FDs such as D $\rightarrow$ CB, A $\rightarrow$ CB …

(Wrong answer: -0.5 point)

(5/10) Consider the relation R(A,B,C,D) with the functional dependencies $AB \longrightarrow C$, $BC \longrightarrow D$, $CD \longrightarrow A$, and $AD \longrightarrow B$. Someone claims that "every subset of {A,B,C,D} that contains two attributes is a key of R if one more functional dependency is added to the above set of functional dependencies". Prove or disprove this claim.

First, we need to see which subset of two elements out of {A,B,C,D} are keys of the relation. We compute

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

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

Since there is no FD with only one attribute in the left hand side, we can conclude that there is no key of R that contains only one attribute. This implies that {A,B}, {A,D}, {B,C}, and {C,D} are keys of R since they functionally determine all attributes of R and they are minimal.

The claim is true if we can find one FD that makes {A,C} and {B,D} keys of R. This means that we need a FD that extends both {A,C} and {B,D}. This can be achieved by one FD whose left hand side belongs to $\{A,C\} \cap \{B,D\}$. But this set is empty, so we can not find a FD that extends both {A,C} and {B,D}. The claim is indeed not true.

Remark: Adding a rule of the form $\varnothing \rightarrow A$, $\varnothing \rightarrow B$, $\varnothing \rightarrow C$, or $\varnothing \rightarrow D$ does not solve the problem either. What we need is something like $\varnothing \rightarrow AD$, $\varnothing \rightarrow BC$, $\varnothing \rightarrow AD$, or $\varnothing \rightarrow AB$. However, adding one of these, say $\varnothing \rightarrow AD$, will make AD no longer the key. So, this will not work as well. [You do not need to have the 'remark' in your answerJ]

GRADE: Correctly computing the above 0.5/1 point each, identifying 4 keys and 2 non-keys 1 point/2 points, give the reason for disagreeing 1 point/2 points

Show that the following rule is not a valid rule about functional dependencies:

If AB C then A C or B C.

(This can be proven by giving an example in which the functional dependency AB C holds but neither A C nor B C holds.)

A	B	C
1	2	3
1	3	4
2	3	5

This instance satisfies AB $\rightarrow$C but does not satisfy A $\rightarrow$C (because of the first two rows). It does not satisfy B $\rightarrow$C either (because of the last two rows)

Give example with AB $\rightarrow$C (2 points), A $\rightarrow$C, B $\rightarrow$C doesn’t hold 1.5 point each.