

Hand in a hardcopy of your answers (printed or handwritten). Include your name, and be sure to clearly identify which problems you are answering and which homework the problems are from since problems from multiple homeworks will be collected at the same time. These problems will be collected on Monday 10/5 and Monday 10/12.

You can hand-draw the ER/EER diagrams, though you are encouraged to use PlantUML to draw the diagrams instead — PlantUML does the layout so you don't have to spend time formatting, and it is easy to edit your diagrams. Instructions for setting up and using PlantUML can be found on Canvas.

Notation note: The ER/EER diagrams are drawn with PlantUML so bold lines are substituted for double lines. In addition, red highlights are also included to make the bold lines easier to see. Note that a limitation in PlantUML means that for specializations, the properties of the line itself can't be changed so the circle at the end of the line is highlighted in red instead.

1. For each of the following statements, determine whether it is
 - *allowed* — true in at least one valid instance of the data but not in every valid instance of the data,
 - *required* — true in every valid instance of the data, or
 - *forbidden* — not true in any valid instance of the data

according to the EER diagram in figure 1. Also give a brief justification for your answer, referencing the specific element(s) in the diagram that it depends on.

- (a) A person is both a faculty member and a student.
- (b) A person is not a faculty member, a staff member, or a student.
- (c) A student is both an undergraduate and a graduate student.
- (d) A student is neither an undergraduate nor a graduate student.
- (e) An undergraduate is also a faculty member.
- (f) A teaching assistant is a graduate student.
- (g) A teaching assistant is a staff member but not a graduate student.
- (h) A graduate student who is also a staff member is a teaching assistant.
- (i) An undergraduate has an advisor.
- (j) A teaching assistant has an advisor.

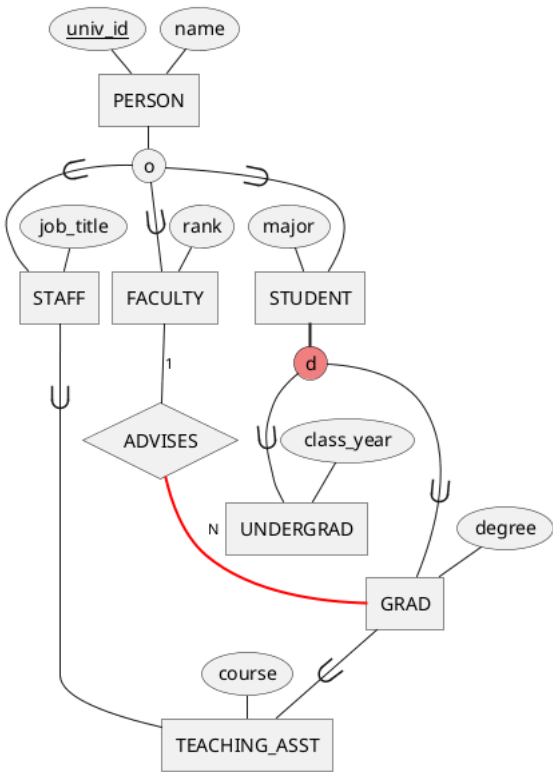


Figure 1: EER diagram for question 1.

2. For each of the following statements, determine whether it is
- *allowed* — true in at least one valid instance of the data but not in every valid instance of the data,
 - *required* — true in every valid instance of the data, or
 - *forbidden* — not true in any valid instance of the data

according to the EER diagram in figure 2. Also give a brief justification for your answer, referencing the specific element(s) in the diagram that it depends on.

- A reserve item is both a book and a DVD.
- A book in the library is not a reserve item.
- A reserve item that is a DVD has an ISBN.
- A laptop is placed on reserve as a reserve item.
- A book is available in a form other than print or an e-book.

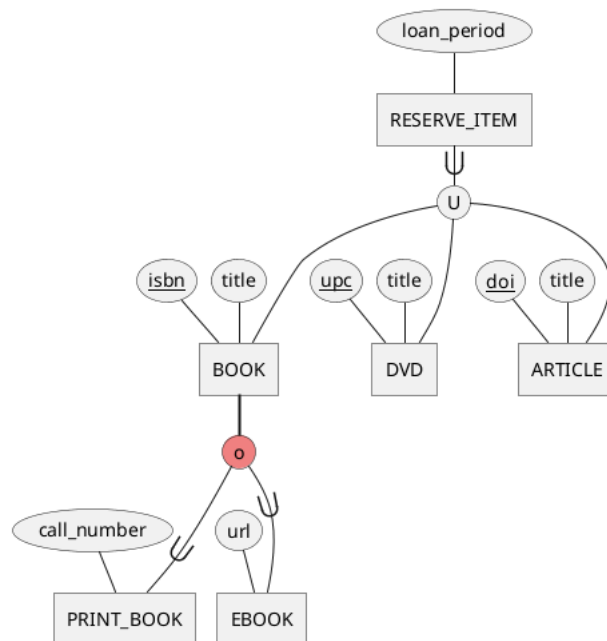


Figure 2: EER diagram for question 2.

For each of the following scenarios:

- (a) Draw an ER/EER diagram to model what is described. Is specialization/generalization or a category (union type) more appropriate? Represent the situation as accurately as possible, including participation, cardinality, key, disjoint/overlapping, and total/partial constraints as appropriate.
- (b) Explain why your choice of specialization/generalization or category (union type) is more appropriate than the alternative.

If more than one design is reasonable for a scenario, choose the design you think is best for the diagram and discuss the tradeoff with the alternative in part (b).

3. Each bill at a hospital has a date, an amount, and exactly one responsible payer. A payer may be the patient (medical record number, name), an insurance company (company name), or an employer covering a workplace injury (EIN, company name). Most patients never pay a bill themselves, and many insurers and employers in the database have no bills with this hospital.
4. Every participant in a community theater company has a name and phone number. Actors have a vocal range, crew members belong to a department, and pit musicians play one or more instruments. Many members act in one show and run lights in the next, and some actors also play in the pit. New members may join before taking on any role.
5. Every employee of an engineering firm has an employee ID, name, and salary. Engineers have a license number. Managers have a budget. Some employees are engineering managers: they are both engineers and managers, and they also hold a technical-leadership certification.
6. A store keeps track of its sales, each of which has a date and a total. A customer may split the total amount of a sale across multiple payments, for example, paying part by card and part in cash. Each payment has an amount and a date and pays toward exactly one sale. Every payment is made by exactly one method: card, check, or cash. For a card payment, the last four digits of the card are kept. A check payment has a check number, and a cash payment has the amount tendered.
7. Members of a fitness club (name, email) can book tennis courts (court number, surface), personal trainers, and equipment such as rowing machines (serial number, model). Trainers are employees of the club. Every employee has an employee ID, name, and salary, and each trainer has a specialty. Every court, trainer, and piece of equipment that can be booked has an hourly rate. A booking is made by one member for a particular date and start time.

For each of the following scenarios, draw an ER/EER diagram to model what is described. Represent the situation as accurately as possible, including participation, cardinality, key, disjoint/overlapping, and total/partial constraints as appropriate. Separately identify any attributes which are required (i.e. should be NOT NULL) and note any other constraints present that you did not capture in the diagram along with a reason why they were omitted. If necessary specifics are lacking in the description of the situation, make reasonable assumptions and state those assumptions.

8. Design a database to keep track of information for an art museum:

- The museum has a collection of art objects, each of which has a unique ID number, an artist (if known), the year it was created (if known), a title, and a description. In addition, there is a country or culture of origin (Italian, Egyptian, American, Indian, etc) and time period (Renaissance, Modern, Ancient, etc).
- For artists, there is a name, date of birth (if known), date of death (if not living), country, period (Renaissance, Modern, Ancient, etc), main style, and description. The name is assumed to be unique.
- An art object is either a painting, a sculpture, a statue, or "other" (for objects that don't fall into one of the other three categories).
 - A painting has a type (oil, watercolor, etc), material (paper, canvas, wood, etc), and style (modern, abstract, etc).
 - A sculpture or statue has a material (wood, stone, etc), height, weight, and style.
 - All other art objects have a type (print, photo, etc) and style.
- Art objects either belong to the permanent collection or are borrowed.
 - For objects in the permanent collection, the date acquired, status (on display, on loan, or stored), and cost are recorded.
 - For objects on loan, the museum that the object is loaned to and the loan period (start and end dates) are recorded. The museum is identified by a name; contact information (a name, an address, and a phone number) and a description are also recorded.
 - For borrowed objects, the owner, date borrowed, and date returned (if applicable) are recorded. The owner of a borrowed object can be an individual or another museum. In both cases, there is a name (unique) and contact information (a name, an address, and a phone number). For a museum, there is also a description.
- Different exhibitions occur, each having a name, start date, and end date. Any object can be part of an exhibition.

9. An automobile repair shop needs to keep information about its operations. Customers initially bring their cars to the shop for an estimate of repairs. A mechanic looks at the car and estimates the cost and time required for the entire job. A job might include several repairs (e.g. replacing the left fender, painting the passenger door) and may include both body work and mechanical repairs. If the customer accepts the estimate, a job number is assigned and the customer's name and contact information; the car's license plate number, make, model, and year; and a list of the repairs needed are recorded. The customer then makes an appointment to bring in the car on a specified date. When the car is brought in for repairs, a technician and/or a mechanic is assigned to work on the car. (Body work can be done by a technician or a mechanic, but mechanical repairs require a licensed mechanic.) The shop keeps track of the charges for parts and labor as they accumulate. The time actually spent for each repair is recorded and used to calculate the cost of labor, using a fixed hourly rate. When the work is complete, the shop produces an itemized bill for the customer showing the part(s) required, the cost of each part, the total labor hours and cost, and the name of the technician/mechanic who completed that repair for each of the repairs in the job.