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# Using the Crow’s Foot methodology, create an ERD that can be implemented for a medical clinic, using *at least* the following business rules:

* A patient can make many appointments with one or more doctors in the clinic, and a doctor can accept appointments with many patients. However, each appointment is made with only one doctor, and each appointment references a single patient.
* Emergency cases do not require an appointment. However, an emergency is entered into the appointment book as "unscheduled" for appointment management purposes.
* If kept, an appointment yields a visit with the doctor specified in the appointment. The visit yields a diagnosis and, when appropriate, treatment.
* Each visit updates the patient's records to provide a medical history.
* Each patient visit creates a bill. Each patient visit is billed by one doctor, and each doctor can bill many patients.
* Each bill must be paid. However, a bill may be paid off in many installments, and a payment may cover more than one bill.
* A patient may pay the bill directly, or the bill may be the basis for a claim submitted to an insurance company.
* If the bill is paid by an insurance company, the deductible is submitted to the patient for payment.

 The ERD

# Tiny College is so pleased with your design and implementation of its student registration/ tracking system that it wants you to expand the design to include its motor pool. A brief description of operations follows:

Faculty members may use the Tiny College-owned vehicles for officially-sanctioned travel. For example, its vehicles may be used by faculty members to travel to off-campus learning centers, to travel to locations at which research papers are presented, to transport students to officially sanctioned locations, and to travel for public service purposes. The vehicles used for such purposes are managed by Tiny College's TFBS (Travel Far But Slow) Center.

Using reservation forms, each department may reserve vehicles for its faculty, who are responsible for filling out the appropriate trip completion form at the end of each trip. The reservation form includes the expected departure date, vehicle type required, destination, and the authorized faculty member. When the faculty member arrives to pick up the vehicle, (s)he must sign a check-out form to log the vehicle out and to pick up a trip completion form. (The TFBS employee who releases the vehicle for use also signs the check-out form.) The faculty member's trip completion form includes the faculty member's identification code, the vehicle's identification, the odometer readings at the start and end of the trip, maintenance complaints, if any, gallons of fuel purchased, if any, and the Learnwell College credit card used to pay for such fuel. If fuel has been purchased, the credit card receipt must be stapled to the trip completion form. Upon receipt of the Faculty Trip Completion form, the faculty member's department is billed at a mileage rate based on the vehicle type (sedan, station wagon, panel truck, minivan, minibus) used. *HINT: Do NOT use more entities than are necessary. Remember the difference between attributes and entities!*

All vehicle maintenance is performed by TFBS. Each time a vehicle requires maintenance, a maintenance log entry is completed on a pre-numbered maintenance log form. The maintenance log form includes the vehicle identification, a brief description of the type of maintenance required, the initial log entry date, the date on which the maintenance was completed, and the identification of the mechanic who released the vehicle back into service. (Only mechanics who have an inspection authorization may release the vehicle back into service.)

As soon as the log form has been initiated, the log form's number is transferred to a maintenance detail form; the log form's number is also forwarded to the parts department manager, who fills out a parts usage form on which the maintenance log number is recorded. The maintenance detail form contains separate lines for each maintenance item performed, the parts used, and the identification of the mechanic who performed the maintenance item. When all the maintenance items have been completed, the maintenance detail form is stapled to the maintenance log form, the maintenance log form's completion date is filled out, and the mechanic who releases the vehicle back to service signs the form. The stapled forms are then filed, to be used later as the source for various maintenance reports.

TBFS maintains a parts inventory, including oil, oil filters, air filters, belts of various types, and so on. The parts inventory is monitored daily to monitor parts usage and to re-order parts that reach the "minimum quantity on hand" level. To track parts usage, the parts manager requires each mechanic to sign out the parts that are used to perform each vehicle's maintenance; the parts manager records the maintenance log number under which the part is used.

Each month, TFBS issues a set of reports. These reports include the mileage driven by vehicle, by department, and by faculty members within the department. In addition, various "revenue" reports are generated by vehicle and department. A detailed parts usage report is also filed each month. Finally, a vehicle maintenance summary is created each month.

Given this brief summary of operations, draw the appropriate (and fully-labeled!) E-R diagram. Use the Chen methodology to indicate entities, relationships, connectivities, and cardinalities.



The ERD

Figure P3.11's E-R diagram has been rendered at the implementation level. That is, we have converted all composite entity relationships by naming them, thus eliminating the need to show the diamonds within the boxes. The following conditions are reflected within the E-R diagram:

* Because a vehicle can require maintenance many times and each maintenance procedure requires a new log entry, the relationship between VEHICLE and LOG is 1:M. Because even a new vehicle is checked initially through the maintenance department, the relationship is mandatory.
* The MAINTENANCE entity is shown as weak to LOG, because the maintenance detail is defined partially by the log number and, quite clearly, a maintenance detail form is existence-dependent on the log entry.
* Some maintenance does not require parts. For example, the adjustment of a fuel injector jet only requires a mechanic's time. Therefore, PART is optional to MAINTENANCE in this relationship. On the other hand, a given vehicle may use many parts during a maintenance operation.
* If a part is required, it must be signed out. Any part can be signed out many times. For example, if the parts inventory includes 25 hose clamps, a hose clamp can be signed out 25 times. (Not the *same* one, of course.... but each time a hose clamp is used, that hose clamp part number shows up in the SIGN\_OUT!)
* Each maintenance line must be signed off by a mechanic and, if a mechanic does any maintenance work, that mechanic is required to sign off on that work. If a mechanic performs many tasks on a given vehicle during its maintenance, that mechanic signs off many times, once for each completed task.
* Only mechanics who have an inspection authorization can sign off the LOG, so LOG is optional to MECHANIC in the MECHANIC creates LOG (entry). But a mechanic with an inspection authorization can sign off many logs.
* Not all departments make reservations for the use of Tiny College vehicles, so RESERVATION is optional to DEPARTMENT. On the other hand, if a reservation is made, it must have been made by a department, so DEPARTMENT is mandatory to RESERVATION.
* Faculty members *may* take many trips during some period of time, thus generating many check-outs. However, not all faculty members use the Tiny College vehicles, so CHECK\_OUT is optional to FACULTY.
* Each check-out generates a charge and each charge is related to one check-out.
* Each charge is determined by the number of miles driven (recorded in CHECK\_OUT) and the charge per mile recorded by vehicle TYPE.

The students may find it helpful if the instructor also shows the composite relationships at the (more conceptual) composite level. It may also be useful to show several different types of composite entities that perform the same kinds of functions. For example, note the similarities between the E-R segments shown in Figure P3.10A.