1 A library database schema contains the following tables:

```
LIB-MEMBER(ID, name, age)
BOOK(serial#, title, author, year-of-publication)
LOAN(ID, serial#, date-due)
```

State what each of the following relational algebra queries is looking for:

(i) $\pi_{name}((\sigma_{year\text{-}of\text{-}publication<1960}\ BOOK \bowtie LOAN) \bowtie LIB\text{-}MEMBER)$

(ii) $\pi_{ID}(\sigma_{age<21}\ LIB\text{-}MEMBER) - \pi_{ID}(\sigma_{author="J.K.Rowling"}\ BOOK \bowtie LOAN)$

(iii) $\pi_{name}((\pi_{ID,serial\#}\ LOAN \div \pi_{serial\#}\ (\sigma_{title\ like\ 'C\ Progamming'}BOOK)) \bowtie LIB\text{-}MEMBER)$

2 The schema of a database containing university-type data is given below. Primary key is underlined for each relation.

```
STUDENT(Sid, Sname, Sex, Age, Year, GPA)
DEPT(Dname, Numphds)
PROF(Pname, Dname)
COURSE(Cno, Cname, Dname)
MAJOR(Dname, Sid)
SECTION(Dname, Cno, Sectno, Pname)
ENROLL(Sid, Grade, Dname, Cno, Sectno)
```

Write the following queries in relational algebra.

(i) Find the names of professors who work in departments that have fewer than 50 PhD students.

(ii) Find the name(s) of student(s) with the lowest GPA.

(iii) Find the names and majors of students who have taken the 'Database System' course.

(iv) Find the ids, names, and GPAs of the students who have taken all courses from the 'Civil Engineering' department.

3 Consider the following relational schema (primary keys are underlined). `eventtype` can take values: *SWI (swimming), ATH (athletics), GYM (gymnastics),* etc. medal can take values: *gold, silver, bronze*. You may assume player names are unique.

```
PLAYERS(player-id, name, countryname, age)
EVENTS(event-id, name, eventtype)
RESULTS(player-id, event-id, medal)
```

Write relational algebra expression for the following queries.

(i) Find the names of the players who won at least one gold and one silver.
(ii) Find the players who did not win a medal.
(iii) Find the names of all the players with the minimum age.

4 Give a relational algebra expression to find the maximum value in the relation `R(A)` *without using aggregate operations*.