University of Toronto
CSC343, Fall 2016

Assignment 1:
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Unary operators on relations:

- $\Pi_{x,y,z}(R)$
- $\sigma_{condition}(R)$
- $\rho_{New}(R)$
- $\rho_{New(a,b,c)}(R)$

Binary operators on relations:

- $R \times S$
- $R \bowtie S$
- $R \bowtie_{condition} S$
- $R \cup S$
- $R \cap S$
- $R - S$

Logical operators:

- $\vee$
- $\wedge$
- $\neg$

Assignment:

- $New(a, b, c) := R$

Stacked subscripts:

- $\sigma_{this.something > that.something \wedge \\ this.otherthing \leq that.otherthing}$

Below is the text of the assignment questions; we suggest you include it in your solution. We have also included a nonsense example of how a query might look in LaTeX. We used `\var` in a couple of places to show what that looks like. If you leave it out, most of the time the algebra looks okay, but certain words, *e.g.*, "Offer" look horrific without it.

The characters "\\" create a line break and "[5pt]" puts in five points of extra vertical space. The algebra is easier to read with extra vertical space. We chose "–" to indicate comments, and added less vertical space between comments and the algebra they pertain to than between steps in the algebra. This helps the comments visually stick to the algebra.

Part 1: Queries

1. Find all patients who (a) have had more than 2 different doctors write them a prescription, and (b) have had a narcotic prescribed to them by every doctor who has written them a prescription. A narcotic is a drug whose schedule is "narcotics". Report the patient's OHIP number.

(a) $PatientsMoreThan2DifferentDoctors(patient) := \Pi_{P1.patient}$
$\sigma_{P1.patient=P2.patient \wedge P2.patient=P3.patient \wedge P1.parent=P3.patient \wedge P1.doctor \neq P2.doctor \wedge P2.doctor \neq P3.doctor \wedge P1.doctor \neq P3.doctor}$
$((\rho_{P1} Prescription) \times (\rho_{P2} Prescription) \times (\rho_{P3} Prescription)$

(b) $A(patient, doctor, schedule) := \pi_{Prescription.patient, Prescription.doctor, Product.schedule}$
$\sigma_{Prescription.drug=Product.DIN}(Prescription \times Product)$

$HasPrescribedNotNarcotic(patient, doctor, schedule) := \sigma_{schedule \neq 'narcotic'} A$

$HasPrescribedBoth(patient) := \pi_{A.patient}$
$\sigma_{HasPrescribedNotNarcotic.patient=A.patient \wedge HasPrescribedNotNarcotic.doctor=A.doctor \wedge A.schedule='narcotic'}$
$(HasPrescribedNotNarcotic \times A)$

$HasDoctorNotNarcotic(patient) := (\pi_{patient} HasPrescribedNotNarcotic) - HasPrescribedBoth$

$Result(patient) = (\pi_{patient} A) - HasDoctorNotNarcotic$

2. Find every prescription from 2016 that has never been filled. Report the patient's OHIP number, the prescription ID, prescription date, and drug.

$NotFilled(RxID) := (\pi_{RxID} Prescription) - (\pi_{RxID} Filled)$

$NeverFilledFrom2016(patient, RxID, date, drug) :=$
$\pi_{patient, RxID, date, drug} \sigma_{date.year=2016}(NotFilled \bowtie Prescription)$

3. Find the pharmacist who has trained the most people. Report the pharmacist's OCP number and name.

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4. The "narcotics prescription period" of a doctor for a patient is the time from the first prescription for narcotics from that doctor for that patient to the most recent one. (It would be zero if that doctor wrote only one prescription for narcotics for that patient.) Find all patients who have had narcotics prescribed by two or more doctors, and for whom the narcotics prescription periods never overlap. In other words, if they had narcotics prescribed by n different doctors,

$$[start_1..end_1] < [start_2..end_2] < ... < [start_n..end_n]$$

where $start_i$ and end_i are the start and end of the narcotics prescription period of doctor i for that patient. Notice that we have written strictly less than. This means that if $end_i = start_{i+1}$ we do not consider that the periods overlap. Report the patient's OHIP number.

$NarcoticDrugs(patient, doctor, date) := \pi_{patient,doctor,date}$
$(\sigma_{DIN=drug \wedge schedule='narcotics'}(Prescription \times Product))$

$AtLeast2(patient) := \pi_{N1.patient}$
$(\sigma_{N1.patient=N2.patient \wedge N1.doctor \neq N2.doctor}(\rho_{N1} NarcoticDrugs \times \rho_{N2} NarcoticDrugs))$

$NotMax(patient, doctor, date) := \pi_{P1.patient,P1.doctor,P1.date}$
$\sigma_{P1.patient=P2.patient \wedge P1.doctor=P2.doctor \wedge P1.date<P2.date}$
$((\rho_{P1} NarcoticDrugs) \times (\rho_{P2} NarcoticDrugs))$

$Max(patient, doctor, date) := NarcoticDrugs - NotMax$

$NotMin(patient, doctor, date) := \pi_{P1.patient,P1.doctor,P1.date}$
$\sigma_{P1.patient=P2.patient \wedge P1.doctor=P2.doctor \wedge P1.date>P2.date}((\rho_{P1} NarcoticDrugs) \times (\rho_{P2} NarcoticDrugs))$

$Min(patient, doctor, date) := NarcoticDrugs - NotMin$

$Doctor(patient, doctor, start, end) := \pi_{Min.patient,Min.doctor,Min.date,Max.date}$
$\sigma_{Max.patient=Min.patient \wedge Max.doctor=Min.doctor}(Min \times Max)$

$NotOverLapped(patient) :=$
$\pi_{P1.patient} \sigma_{P1.patient=P2.patient \wedge P1.doctor \neq P2.doctor \wedge ((P1.end \leq P2.start) \vee (P1.start \geq P2.end))}$
$((\rho_{P1} Doctor) \times (\rho_{P2} Doctor))$

$Result(patient) := AtLeast2 \cap NotOverLapped$

5. Find all pharmacists who have never filled a prescription for a drug product whose active ingredient is "codeine". Report their OCP number and every schedule for which they *have* filled a prescription. Put the information into a relation with attributes "OCP" and "schedule".

$FilledPrescriptions(RXID, date, patient, drug, doctor, dosage, note, pharmacist) :=$
$\sigma_{Filled.RxID=Prescription.RxID}(Filled \times Prescription)$

$PharmacistWithCodaine(OCP) :=$
$\pi_{FilledPrescriptions.pharmacist} \sigma_{ActiveIngredient.name='codaine' \wedge FilledPrescriptions.drug=ActiveIngredient.DIN}$
$(FilledPrescriptions \times ActiveIngredient)$

$NotFilledWithCodaine(OCP) := (\pi_{OCP} Pharmacist) - PharmacistWithCodaine$

$PharmacistFilledProduct(drug, OCP) :=$
$\pi_{FilledPrescriptions.drug, FilledPrescriptions.pharmacist}$
$\sigma_{FilledPrescriptions.pharmacist=NotFilledWithCodaine.OCP}(FilledPrescriptions \times NotFilledWithCodaine)$

$Result(OCP, schedule) := \pi_{PharmacistFilledProduct.OCP, Product.schedule}$
$\sigma_{Product.DIN=PharmacistFilledProduct.drug}(Product \times PharmacistFilledProduct)$

6. Lets say a minor trainer is a pharmacist who has trained no more than two people. (They may have trained none.) Find all pharmacists who have trained 2 or more minor trainors. (They may have trained other pharmacists who were not minor trainors.) Report the pharmacist's OCP number.

$AtLeastThrice(OCP) := \pi_{T1.P2}$
$\sigma_{T1.P2=T2.P2 \wedge T2.P2=T3.P2 \wedge T1.P2=T3.P2 \wedge T1.P1 \neq T2.P1 \wedge T2.P1 \neq T3.P1 \wedge T1.P1 \neq T3.P1}((\rho_{T1} TrainedUnder) \times (\rho_{T2} TrainedUnder) \times (\rho_{T3} TrainedUnder))$

$MinorTrainer(OCP) := (\pi_{OCP} Pharmacist) - AtLeastThrice$

$Trained1MinorTrainer(P1, P2) := \pi_{P1,P2}$
$\sigma_{TrainedUnder.P1=OCP}(MinorTrainer \times TrainedUnder)$

$TrainedTwoOrMoreMinorTrainer(P2) :=$
$\pi_{T1.P2}\sigma_{T1.P2=T2.P2 \wedge T1.P1 \neq T2.P1}(\rho_{T1} Trained1MinorTrainer) \times (\rho_{T2} Trained1MinorTrainer))$

7. Find the most junior pharmacist: the pharmacist whose first time filling a prescription has the latest date. Report the pharmacist's OCP number, the prescription ID for the first prescription they filled, the date on which it was written, and the date on which it was filled.

$NotFirstFillingPrescription(RxID, date, pharmacist) := \pi_{F1.RxID, F1.date, F1.pharmacist}$
$\sigma_{F1.pharmacist=F2.pharmacist \wedge F1.date > F2.date}((\rho_{F1} Filled) \times (\rho_{F1} Filled))$

$FirstFillingPrescription(RxID, date, pharmacist) := Filled - NotFirstFillingPrescription$

$NotJunior(RxID, date, pharmacist) :=$
$\pi_{P1.RxID, P1.date, P1.pharmacist}\sigma_{P1.RxID \neq P2.RxID \wedge P1.pharmacist \neq P2.pharmacist \wedge P1.date < P2.date}$
$((\rho_{P1} FirstFillingPrescription) \times (\rho_{P2} FirstFillingPrescription))$

$Junior(RxID, date, pharmacist) := FirstFillingPrescription - NotJunior$

$Result(OCP, RxID, writtendate, filleddate) := \pi_{Junior.pharmacist, Junior.RxID, Prescription.date, Junior.date}$
$\sigma_{Junior.RxID=Prescription.RxID}(Junior \times Prescription)$

8. Find every patient who has had a prescription for a homeopathic drug product filled, that is, a product whose schedule is "homeopathic", but has never had a prescription filled for a drug product with any other schedule.

$FilledPrescription = \sigma_{Prescription.RxID=Filled.RxID}(Prescription \times Filled)$

$PatientWithFilledPrescription(patient) = \pi_{patient} FilledPrescription$

$PatientFilledOtherSchedule(patient) = \pi_{Filled.patient}$
$\sigma_{FilledPrescription.drug=Product.DIN \wedge schedule \neq 'homeopathic'}(FilledPrescription \times Product)$

$OnlyHadHomeopathic(patient) := PatientWithFilledPrescription - PatientFilledOtherSchedule$

9. Find all patients who have had at least two prescriptions for narcotics that have a single active ingredient, whose units are mg, and for whom the dosage of the ingredient in these prescriptions never decreased from one prescription to the next. Report their OHIP number.

$---------Part1---------$

$\sharp$ *All prescriptions that schedule of the drug is narcotic*
$PrescribedNarcotic(RxID, date, patient, DIN, dosage) :=$
$\pi_{RxID,date,patient,DIN,dosage} \sigma_{drug=DIN \wedge schedule='narcotic'}(Prescription \times Product)$

$\sharp$ *The drugs which have two ingredients and whose units are mg*
$NotSingleActive(DIN, name, unit) :=$
$\pi_{P1.DIN,P1.name,P1.unit} \sigma_{P1.DIN=P2.DIN \wedge P1.name \neq P2.name \wedge P1.unit='mg' \wedge P2.unit='mg'}$
$((\rho_{P1} ActiveIngredient) \times (\rho_{P2} ActiveIngredient))$

$\sharp$ *Drugs that have only a single active ingredient.*
$SingleActive(DIN, name, unit) := (\pi_{DIN,name,unit} ActiveIngredient) - NotSingleActive$

$\sharp$ *Drugs that have only a single active ingredient whose units are mg*
$SingleActiveMg(DIN, name, unit) := \sigma_{unit='mg'} SingleActive$

$\sharp$ *Patients that have prescribed a drug that contains a single ingredient and schedule of the drug is narcotic.*

$PatientsWithSingleIngredientNarcotic(RxID, date, patient, DIN, dosage) :=$
$\pi_{S.RxID,S.date,S.patient,S.DIN,P.dosage}((\rho_S SingleActiveMg) \bowtie (\rho_P PrescribedNarcotic))$

♯ *Patients who have had at least two prescriptions for narcotics that have single active ingredient whose units are mg.*

$PatientsAtLeastTwoSingle(date, patient, dosage) :=$
$\pi_{P1.date,P1.patient,P1.dosage}\sigma_{P1.DIN\neq P2.DIN\wedge P1.RxID\neq P2.RxID}$
$((\rho_{P1}PatientsWithSingleIngredientNarcotic)\times(\rho_{P2}PatientsWithSingleIngredientNarcotic))$

$---------Part2---------$

$PatientAndDosagesSortedByDate(patient, nextdosage, firstdosage) :=$
$\pi_{P1.patient,P1.dosage,P2.dosage}\sigma_{P1.patient=P2.patient\wedge P1.date>P2.date}$
$((\rho_{P1}PatientsAtLeastTwoSingle) \times (\rho_{P2}PatientsAtLeastTwoSingle))$

$PatientsThatDontSatisfy(patient) :=$
$\pi_{A1.patient}\sigma_{A1.nextdosage<A1.firstdosage}(\rho_{A1}PatientAndDosagesSortedByDate)$

$Result(patient) :=$
$(\pi_{patient}PatientAndDosagesSortedByDate) - PatientsThatDontSatisfy$

10. Let's say a pharmacist X is a descendant of Y if either X trained under Y, or X trained under someone else who is a descendant of Y. Report the OCP number of everyone who is a descendant of the pharmacist with OCP number 55555.

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11. For each pharmacist who has trained anyone, report their OCP number, the OCP number of the first person to complete training under them, and the OCP number of the last person to complete training under them. Your resulting relation should have three attributes: "OCP", "first" and "last".

    $NotLast(P1, P2) := \pi_{T1.P1,T1.P2}\sigma_{T1.P2=T2.P2\wedge T1.completed<T2.completed}$
    $((\rho_{T1}TrainedUnder) \times (\rho_{T2}TrainedUnder))$

    $NotFirst(P1, P2) := \pi_{T1.P1,T1.P2}\sigma_{T1.P2=P2.P2\wedge T1.completed>T2.completed}$
    $((\rho_{T1}TrainedUnder) \times (\rho_{T2}TrainedUnder))$

    $Last(P1, P2) := (\pi_{P1,P2}TrainedUnder) - NotLast$

    $First(P1, P2) := (\pi_{P1,P2}TrainedUnder) - NotFirst$

    $Result(OCP, first, last) := \pi_{First.P2,First.P1,Last.P1}\sigma_{First.P2=Last.P2}(First \times Last)$

12. Find all people who have, at least twice, had more than one prescription filled in a year, but haven't had one filled since 2014. Report the person's OHIP number and the last date on which they had a prescription filled.

$FilledPrescriptions(date, RxID, patient) :=$
$\pi_{date,RxID,patient}\sigma_{Filled.RxID=Prescription.RxID}(Filled \times Prescription)$

$MoreThanOneInAYear(RxID, date, patient) :=$
$\pi_{F1.RxID \wedge F1.date,F1.patient}\sigma_{F1.date.year=F2.date.year \wedge F1.RxID \neq F2.RxID \wedge F1.patient=F2.patient}$
$((\rho_{F1}FilledPrescriptions) \times (\rho_{F2}(FilledPrescriptions))$

$AtLeastTwice(patient) :=$
$\pi_{M1.patient}\sigma_{M1.patient=M2.patient \wedge M1.RxID \neq M2.RxID \wedge M1.date.year \geq M2.date.year}$
$((\rho_{M1}MoreThanOneInAYear) \times (\rho_{M2}(MoreThanOneInAYear))$

$HaveFilledSince2014(patient) :=$
$\pi_{patient}\sigma_{date.year \geq 2014}(FilledPrescriptions)$

$HaventFilledSince2014(patient) := (\pi_{patient}FilledPrescription) - HaveFilledSince2014$

$AtLeastTwiceandHaventFilled(patient) := AtLeastTwice \cap HaventFilledSince2014$

$PatientsPrescriptions(patient, date) :=$
$\pi_{Result.patient,Filled.Date}$
$\sigma_{Result.patient=FilledPrescriptions.patient}(AtLeastTwiceandHaventFilled \times FilledPrescriptions)$

$NotLastPrescription(patient, date) := \pi_{P1.patient,P1.date}$
$\sigma_{P1.patient=P2.patient \wedge P1.date<P2.date}((\rho_{P1}PatientsPrescriptions) \times (\rho_{P2}PatientsPrescriptions))$

$Result(patient, date) = PatientsPrescriptions - NotLastPrescription$

Part 2: Additional Integrity Constraints

1. A pharmacist can only train under someone who registered with the Ontario College of Physicians before they did.

$\sigma_{A1.OCP=P1 \wedge A2.OCP=P2 \wedge A1.registered \leq A2.registered}$
$(TrainedUnder \times (\rho_{A1}Pharmacist) \times (\rho_{A2}Pharmacist)) = \emptyset$

2. A doctor can't prescribe a controlled substance (a product with schedule "narcotics") until after they have prescribed three different over-the-counter drug products (products with schedule "OTC").

$$ControlledSubstances(DIN) := \pi_{DIN}(\sigma_{schedule='narcotics'}Product)$$

$$DoctorPrescribingControlled(doctor, date) := \pi_{doctor,date}(\sigma_{DIN=drug}ControlledSubstances \times Prescription)$$

$$OTCProducts(DIN, name) := \pi_{DIN,name}\sigma_{schedule='OTC'}Product$$

$$OverTheCounterProducts(name, doctor, date) := \pi_{O.name,P.doctor,P.name}\sigma_{O.DIN=P.drug}((\rho_O OTCProducts) \times (\rho_P Prescription))$$

$$ThreeDiffCounterProducts(doctor, date) := \pi_{P1.doctor,P1.date}$$
$$\sigma_{\substack{O1.name \neq O2.name \wedge O2.name \neq O3.name \wedge O1.name \neq O3.name \\ \wedge O1.doctor = O2.doctor \wedge O2.doctor = O3.doctor \wedge O1.doctor = O3.doctor \wedge P1.date \leq P2.date \leq P3.date}}$$
$$((\rho_{O1}OverTheCounterProducts)$$
$$\times (\rho_{O2}OverTheCounterProducts) \times (\rho_{O3}OverTheCounterProducts))$$

$$\sigma_{D1.doctor = D2.doctor \wedge D1.date < D2.date}$$
$$((\rho_{D1}DoctorPrescribingControlled) \times (\rho_{D2}ThreeDiffCounterProducts)) = \emptyset$$