# Assignment 1

## Part 1: Create an instance

CityInstance

| cityID | name | country |
|---|---|---|
| 1 | Toronto | Canada |
| 2 | Montreal | Canada |

TripInstance

| tripID | startCity | length |
|---|---|---|
| 1 | 1 | 4 |

TransportActivityInstance

| aID | destCity | mode |
|---|---|---|
| 4 | 2 | train |

TourActivityInstance

| aID | name | duration | extra |
|---|---|---|---|
| 1 | ROM | 5 | False |
| 2 | CN Tower | 6 | False |
| 3 | Toronto Zoo | 11 | False |
| 5 | Old Montreal | 5 | False |
| 6 | Mont Royal | 6 | True |

ItineraryInstance

| tripID | day | step | cityID | activityID |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 2 | 1 | 2 |
| 1 | 2 | 1 | 1 | 3 |
| 1 | 3 | 1 | 1 | 4 |
| 1 | 4 | 1 | 2 | 5 |
| 1 | 4 | 2 | 2 | 6 |

StaffInstance

| staffID | name | hireDate |
|---|---|---|
| 1 | Me | 20240101 |

TravellerInstance

| tID | name | email | citizenship |
|---|---|---|---|
| 1 | John Doe | a@mail.com | Canada |
| 2 | Jane Doe | b@mail.com | Canada |
| 3 | Lorem Is | c@mail.com | Canada |

BookingInstance

| bID | tripID | startDate | traveller | bookedBy | price |
|---|---|---|---|---|---|
| 1 | 1 | 20240131 | 1 | 1 | 500 |
| 2 | 1 | 20240131 | 2 | 1 | 500 |
| 3 | 1 | 20240131 | 3 | 1 | 500 |

ExtraBookingInstance

| bID | activity | price |
|---|---|---|
| 3 | 6 | 200 |

## Part 2: Give the output of a query

QueryOutput

| duration |
|---|
| 5 |
| 6 |
| 11 |

## Part 3: Violating a constraint

CityInstance

| cityID | name | country |
|---|---|---|
| 1 | Toronto | Canada |

TripInstance

| tripID | startCity | length |
|---|---|---|
| 1 | 1 | 1 |

StaffRequiredInstance

| activityID | role |
|---|---|
| 1 | Guide |

TourActivityInstance

| aID | name | duration | extra |
|---|---|---|---|
| 1 | CN Tower | 6 | False |

ItineraryInstance

| tripID | day | step | cityID | activityID |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 |

StaffInstance

| staffID | name | hireDate |
|---|---|---|
| 1 | Me | 20240101 |

TravellerInstance

| tID | name | email | citizenship |
|---|---|---|---|
| 1 | John Doe | a@mail.com | Canada |

BookingInstance

| bID | tripID | startDate | traveller | bookedBy | price |
|---|---|---|---|---|---|
| 1 | 1 | 20240131 | 1 | 1 | 500 |

## Part 4: Queries

1. – Every country and tripID tuple where the trip visited the country.

   $Countries(country, tripID) := \Pi_{country,tripID}(City \bowtie Itinerary)$

   – Every tripID that has visited at least three countries.

   $AtLeastThrice(tripID) :=$

   $$\Pi_{T1.tripID}\left[\sigma_{\substack{T1.tripID=T2.tripID=T3.tripID \\ \wedge \\ T1.country<T2.country<T3.country}}\left(\rho_{T1}Countries \times \rho_{T2}Countries \times \rho_{T3}Countries\right)\right]$$

   – Every tripID that has visited at least four countries.

   $AtLeastFour(tripID) :=$

   $$\Pi_{T1.tripID}\left[\sigma_{\substack{T1.tripID=T2.tripID \\ =T3.tripID=T4.tripID \\ \wedge \\ T1.country<T2.country \\ <T3.country<T4.country}}\left(\rho_{T1}Countries \times \rho_{T2}Countries \times \rho_{T3}Countries \times \rho_{T4}Countries\right)\right]$$

   – Every tripID that has visited exactly three countries.

   $ExactlyThree(tripID) := AtLeastThrice - AtLeastFour$

   – The tripID and day of every day in any trip.

   $TripDays(tripID, day) := \Pi_{\text{tripID, day}}Itinerary$

   – The tripID and day of every day that is not the last day in a trip.

   $$NotLastDays(tripID, day) := \Pi_{\substack{\text{T1.tripID,} \\ \text{T1.day}}}(\sigma_{\substack{\text{T1.tripID = T2.tripID} \\ \wedge \\ \text{T1.day<T2.day}}}(\rho_{\text{T1}}\text{TripDays} \times \rho_{\text{T2}}\text{TripDays}))$$

   – The tripID and day of every day that is the last day in a trip.

   $LastDay(tripID, day) := TripDays - NotLastDays$

   – The tripID and step of every step on the last day of any trip.

   $LastDaySteps(tripID, day, step) := \Pi_{tripID,day,step}(LastDay \bowtie Itinerary)$

   – The tripID and step of every step that is not the last step on the last day in a trip.

   $$NotLastStep(tripID, day, step) := \Pi_{\substack{\text{T1.tripID,} \\ \text{T1.day,} \\ \text{T1.step}}}(\sigma_{\substack{\text{T1.tripID = T2.tripID} \\ \wedge \\ \text{T1.step<T2.step}}}(\rho_{\text{T1}}\text{LastDaySteps} \times \rho_{\text{T2}}\text{LastDaySteps}))$$

   – The tripID and step of every last step on the last day in a trip.

   $LastStep(tripID, day, step) := LastDaySteps - NotLastStep$

   – The tripID, cityID, and country of every trip's start city.

   $Renamed(tripID, cityID, country) := \Pi_{tripID,cityID,country}(\rho_{T1(tripID,cityID,length)}Trip) \bowtie City$

   – The tripID, cityID, and country of the start city in a trip that visits exactly three countries.

   $Start(tripID, startCityID, startCountry) := \Pi_{tripID,cityID,country}(Itinerary \bowtie ExactlyThree \bowtie Renamed)$

– The tripID, cityID, and country of the end city in a trip that visits exactly three countries.

$End(tripID, endCityID, endCountry) := \Pi_{tripID,cityID,country}(Itinerary \bowtie ExactlyThree \bowtie LastStep \bowtie City)$

$Start \bowtie End$

2. – The cityID of every city which is not part of any trip.

$NoTrip(cityID) := \Pi_{cityID} City - \Pi_{cityID} Itinerary$
$\Pi_{name,country}(NoTrip \bowtie City)$

3. Cannot be expressed.

4. Cannot be expressed.

5. – The bID, activity, and price of every extra booking that is not the most expensive.

$NotMax(bID, activity, price) :=$

$$\Pi_{T1.bID,T1.activity,T1.price}\left[\sigma_{\substack{T1.bID \neq T2.bID \\ \wedge \\ T1.price < T2.price}}\Big(\rho_{T1} ExtraBooking \times \rho_{T2} ExtraBooking\Big)\right]$$

– The bID, activity, and price of every extra booking with the maximum price.

$Max(bID, activity, price) := ExtraBooking - NotMax$

– The bID, activity, and price of every extra booking that is that is not the second most expensive.

$NotSecond(bID, activity, price) :=$

$$\Pi_{T1.bID,T1.activity,T1.price}\left[\sigma_{\substack{T1.bID \neq T2.bID \\ \wedge \\ T1.price < T2.price}}\Big(\rho_{T1} NotMax \times \rho_{T2} NotMax\Big)\right]$$

– The bID, activity, and price of every extra booking with the second greatest price.

$Second(bID, activity, price) := ExtraBooking - Max - NotSecond$

$$\Pi_{tripID,activity,price}\Big[\Big(Max \cup Second\Big) \bowtie Booking\Big]$$

6. – The staffID of every staff hired before 2020.

$Before2020(staffID) := \Pi_{staffID}(\sigma_{hireDate<20200101} Staff)$

– The staffID and tripID of every 'guide' assignment to a trip where the staff was hired before 2020.

$Guide(staffID, tripID) := \Pi_{staffID,tripID}\Big(\sigma_{role='guide'} StaffAssignment \bowtie Before2020\Big)$

– Every possible combination of staffID and tripID where the staff was hired before 2020.

$EveryPossible(staffID, tripID) := \Pi_{staffID} Before2020 \times \Pi_{tripID} Trip$

– The staffID of the staff who were not assigned as 'guide' to every trip.

$Missing(staffID) := \Pi_{staffID}(EveryPossible - Guide)$

$Before2020 - Missing$

7. Note: I solved this before the clarification that returning to a city previously visited at an earlier date counts as visiting a new city.

$$\Pi_{tripID} Itinerary - \Pi_{T1.tripID}\left[\sigma_{\substack{T1.tripID=T2.tripID \\ \wedge \\ T1.city=T2.city \\ \wedge \\ T1.day<T2.day}}\left(\rho_{T1} Itinerary \times \rho_{T2} Itinerary\right)\right]$$

8. – All bIDs and tripIDs where the booking does not have the earliest start date for the trip.

$$NotEarliestBooking(bID, tripID) := \Pi_{T2.bID,T2.tripID}\left[\sigma_{\substack{T1.tripID=T2.tripID \\ \wedge \\ T1.startDate<T2.startDate}}\left(\rho_{T1} Booking \times \rho_{T2} Booking\right)\right]$$

– All bIDs and tripIDs where the booking has the earliest start date for the trip.

$$EarliestBookings(bID, tripID) := \Pi_{bID,tripID} Booking - NotEarliestBooking$$

– The bIDs of all earliest bookings where their trips are booked by at least two other travellers at later start dates.

$$AtLeastThreePeople(bID) := \Pi_{bID} EarliestBookings \cap$$
$$\Pi_{T1.bID}\left[\sigma_{\substack{T1.tripID=T2.tripID=T3.tripID \\ \wedge \\ T1.startDate<T2.startDate \\ \wedge \\ T1.startDate<T3.startDate \\ \wedge \\ T1.traveller<T2.traveller<T3.traveller}}\left(\rho_{T1} Booking \times \rho_{T2} Booking \times \rho_{T3} Booking\right)\right]$$

– All travellers who are not influencers.

$$NotInfluencers(traveller) := \Pi_{traveller}(\Pi_{traveller,bID} Booking - (\Pi_{traveller} Booking \times AtLeastThreePeople))$$

$$\Pi_{name,email}((\Pi_{traveller} Booking - NotInfluencers) \bowtie Traveller)$$

9. Cannot be expressed.

10. $$\Pi_{T1.staffID,T2.staffID}\left[\sigma_{\substack{T1.staffID<T2.staffID \\ \wedge \\ T1.tripID=T2.tripID \\ \wedge \\ T1.startDate=T2.startDate}}\left(\rho_{T1} StaffAssignment \times \rho_{T2} StaffAssignment\right)\right]$$

## Part 5: Additional integrity constraints

1. – The tripID and day of every first day of a trip listed in Itinerary.

   $FirstDay(tripID, day) := \Pi_{tripID,day} Itinerary -$

   $$\Pi_{T2.tripID,T2.day}\left[\sigma_{\substack{T1.tripID=T2.tripID \\ \wedge \\ T1.day<T2.day}}\left(\rho_{T1}Itinerary \times \rho_{T2}Itinerary\right)\right]$$

   $$\Pi_{tripID}(\sigma_{day>1}FirstDay) \cup \Pi_{tripID}\left(\Pi_{tripID,day}Itinerary - \Pi_{tripID,day}(\sigma_{day=1}Itinerary) -\right.$$

   $$\left.\Pi_{T2.tripID,T2.day}\left[\sigma_{\substack{T1.tripID=T2.tripID \\ \wedge \\ T1.day+1=T2.day}}\left(\rho_{T1}Itinerary \times \rho_{T2}Itinerary\right)\right]\right) = \emptyset$$

2. $\rho_{T1(activityID)}(\Pi_{activity}ExtraBooking) - \Pi_{activityID}Itinerary = \emptyset$

3. $\Pi_{traveller,country}[Booking \bowtie Itinerary \bowtie City] -$

   $$\rho_{T2(traveller,country)}(\Pi_{tID,citizenship}Traveller) - \Pi_{traveller,country}(\sigma_{expiry>startDate}(Visa \bowtie Booking)) = \emptyset$$

4. $$\Pi_{T1.tripID}\left[\sigma_{\substack{T1.tripID=T2.tripID=T3.tripID \\ \wedge \\ T1.day=T2.day=T3.day \\ \wedge \\ T1.country<T2.country<T3.country}}\left(\rho_{T1}(City \bowtie Itinerary) \times \rho_{T2}(City \bowtie Itinerary) \times \rho_{T3}(City \bowtie Itinerary)\right)\right] = \emptyset$$

5. – The tripID, day, and step of every transport activity in the itinerary.

   $TransportItinerary(tripID, day, step) :=$

   $$\Pi_{tripID,day,step,activityID}(Itinerary \bowtie (\rho_{R1(activityID)}\Pi_{aID}TransportActivity))$$

   – The tripID, day, and step of every transport activity that is the last step of a day in a trip.

   $LastStepTransport(tripID, day, step) := TransportItinerary -$

   $$\Pi_{T1.tripID,T1.day,T1.step}\left[\sigma_{\substack{T1.tripID=T2.tripID \\ \wedge \\ T1.day=T2.day \\ \wedge \\ T1.step<T2.step}}\left(\rho_{T1}Itinerary \times \rho_{T2}Itinerary\right)\right]$$

   $$\Pi_{T1.tripID}\left[\sigma_{\substack{T1.tripID=T2.tripID \\ \wedge \\ T1.day=T2.day \\ \wedge \\ T1.step+1=T2.step}}\left(\rho_{T1}TransportItinerary \times \rho_{T2}TransportItinerary\right)\right] \cup$$

   $$\Pi_{T3.tripID}\left[\sigma_{\substack{T3.tripID=T4.tripID \\ \wedge \\ T3.day+1=T4.day}}\left(\rho_{T3}(\Pi_{tripID,day}LastStepTransport) \times \rho_{T4}(\sigma_{step=1}TransportItinerary))\right)\right]$$

   $= \emptyset$

6. Cannot be expressed.