Part 1. Relational Algebra In this problem, you will use a few relations representing some fictitious

Southwest Airlines flights and airplanes. Use only this instance. `flights` contains information about flight routes on a particular day, departure time and the exact aircraft (`tail`) used to fly that particular flight. aircraft contains information about all airplanes that Southwest owns and operates. A smaller relation, `airtran_aircraft` contains information about airplanes that Southwest acquired in its purchase of Airtran in 2011. Tuples in `airtran_aircraft` also appear in `aircraft` if they were acquired by Southwest. [If curious, the aircraft types are described as B73G (Boeing 737-700), B738 (Boeing 737-800) and B38M (Boeing 737 MAX 8, or 737-8).]

from	to	flightnum	departure	tail
LAX	SFO	181	8am	N8751R
LAX	SJC	185	9am	N705SW
SJC	LAX	186	10am	N404WN
BUR	SJC	191	11am	N957WN
LAX	ATL	993	12pm	N7851A
MCO	CUN	991	1pm	N7827A
SJC	BUR	192	2pm	N709SW
SFO	LAX	182	3pm	N8751R
SJC	DAL	94	4pm	N705SW
SJC	PHX	99	5pm	N957WN

tail	type
N404WN	B73G
N705SW	B73G
N709SW	B73G
N8751R	B73G
N7851A	B38M
N7827A	B73G
N7854B	B73G
N7826B	B73G
N957WN	B738

tail	type
N7851A	B73G
N7827A	B73G
N7854B	B73G
N7826B	B73G

Exercises.

(a) Write a relational algebra expression that returns the number of flights flown by each `type` of aircraft. A flight is uniquely identified by its flight number (denoted `flightnum`). Each flight number is used for one take off and one landing. Your result should provide insight like "4 flights were flown by an airplane that is of type B738." `flightnum` is a flight number (i.e. Southwest flight 181) and not the number of flights flown.

Response:

$$_{\texttt{type}}\gamma_{\texttt{flights.tail}\rightarrow\texttt{count}}(\texttt{flights} \bowtie_{\texttt{(flights.tail = aircraft.tail)}} \texttt{aircraft} \cup \texttt{flights} \bowtie_{\texttt{(flights.tail = airtran\_aircraft.tail)}} \texttt{airtran\_aircraft})$$

(b) In 2011, Southwest Airlines acquired Airtran. The relation `aircraft` contains Southwest owns, including those acquired from Airtran. The relation `airtran_aircraft` includes information about *only* Airtran's aircraft. Write a relational algebra expression that returns all flight numbers (`flightnum`) operated by aircraft that were *not* operated by Airtran.

Response:

$$\Pi_{\texttt{flightnum}}(\texttt{flights} \bowtie_{\texttt{(flights.tail = aircraft.tail)}} [\texttt{aircraft - airtran\_aircraft}])$$

(c) Most aircraft fly multiple routes in one day. For example, tail N705SW flies from LAX (Los Angeles) to SJC (San Jose, CA) and then flies from SJC (San Jose) to DAL (Dallas). Such schedules form a graph. Write the relational algebra expression that return the tail and where each plane starts and ends up after two flights: tail, origin (`from`), and `final_destination` (to after 2 flights). In the example earlier, the query would return N705SW, LAX and DAL since it started at LAX and ended up at DAL after two flights. A couple of notes and hints: (1) if a tail only flew one flight, it would not appear in the output, (2) you are essentially traversing a graph, and this is an example of a *self join*, (3) you need to somehow use the departure time and this is an example of a *non-equi-join*. Be very careful with aliasing and renaming in this problem.