Note: Collaboration on assignments is encouraged, but you must write up your work individually and in your own words.

1. **(Relational Algebra)**

   Consider the relational database schema {CUSTOMER, ORDER, DRIVER} with the relation schemata:

   - CUSTOMER=$\{customer\_id, name, email\}$ with key {customer_id}

   - DRIVER=$\{date, driver\_name, vehicle\}$ with key {date}

   - ORDERS=$\{order\_id, customer\_id, address, payment\_method, order\_date\}$ with key {order_id}
   and with foreign keys

   $$[customer\_id] \subseteq \texttt{CUSTOMER}[customer\_id]$$
   $$[order\_date] \subseteq \texttt{DRIVER}[date]$$

   (a) For the following English language description of a query write the corresponding <u>relational algebra</u> query. Only use operators of relational algebra that were used in the lecture.

   i) Which are the orders (the order_ids) that have been delivered by neither the driver 'Karl' nor 'Lenny' (not been delivered by 'Karl' or 'Lenny')?

   [4 marks]

   ii) Who are the drivers that have never driven a bus and drove a motorbike when they delivered an order to the address '742 Evergreen Tce'?

   [4 marks]

   (b) Write down an <u>English language description</u> of the query that is equivalent to the following relational algebra query:

   i) $Q_1 = \pi_{address}(\texttt{ORDERS} \bowtie (\sigma_{driver\_name='Karl'}(\texttt{DRIVER})))$
   $Q_2 = \pi_{address}(\sigma_{payment\_method='cash'}\texttt{ORDERS})$
   $Q = Q_1 - Q_2$

   [3 marks]

   ii) $\pi_{name,email}(\texttt{CUSTOMER} \bowtie (\pi_{customer\_id,payment\_method}(\texttt{ORDERS}) \div \pi_{payment\_method}(\texttt{ORDERS})))$

   [3 marks]

SOLUTION:

(a) i)

$Q_1 = \pi_{date}(\sigma_{driver\_name='Karl'}(\texttt{DRIVER}) \cup \sigma_{driver\_name='Lenny'}(\texttt{DRIVER}))$
$Q_2 = \pi_{date}(\texttt{DRIVER})$ - Q_1
$Q = \pi_{order\_id}(\texttt{ORDERS} \bowtie Q_2)$

ii)

$Q_1 = \pi_{driver\_name}((\sigma_{address='742EvergrenTce'}(\texttt{ORDERS})) \bowtie (\sigma_{vehicle='motorbike'}(\texttt{DRIVER})))$
$Q_2 = \pi_{driver\_name}(\sigma_{vehicle='bus'}(\texttt{DRIVER}))$
$Q = Q_1 - Q_2$

(b) i)

What are the addresses that driver Karl has delivered to of orders that have not been paid in cash?

ii)

What are the name and email of those customers that used every payment method?

2. **(Relational Calculus)**

   Consider the relational database schema {CUSTOMER, ORDER, DRIVER} with the relation schemata:

   - CUSTOMER={*customer_id, name, email*} with key {customer_id}

   - DRIVER={*date, driver_name, vehicle*} with key {date}

   - ORDERS={*order_id, customer_id, address, payment_method, order_date*} with key {order_id}
   and with foreign keys

   > [customer_id] $\subseteq$ CUSTOMER[customer_id]
   >
   > [order_date] $\subseteq$ DRIVER[date]

   (a) Write the following query in safe relational calculus:

   Who are the customers that have ordered on April 1st 2024 (2024-04-01) and paid in cash?

   [3 marks]

   (b) Write down in English what the following relational calculus query returns:

   $\text{CUSTOMER}(x_{customer\_id}, x_{name}, x_{email}) \wedge$
   $\forall x_{order\_id}, x_{address}, x_{payment\_method}, x_{order\_date}, x_{date}$
   $((\text{ORDERS}(x_{order\_id}, x_{customer\_id}, x_{address}, x_{payment\_method}, x_{order\_date}) \Rightarrow$
   $\exists x_{vehicle} \text{ DRIVER}(x_{date}, \text{'Karl'}, x_{vehicle})) \wedge (x_{order\_date} = x_{date}))$

   [3 marks]

SOLUTION:

   (a) $\exists x_{customer\_id}, x_{email}, x_{order\_id}, x_{address} (\text{CUSTOMER}(x_{customer\_id}, x_{name}, x_{email}) \wedge$
   $\text{ORDERS}(x_{order\_id}, x_{customer\_id}, x_{address}, \text{'cash'}, 2024\text{-}04\text{-}01)$

   (b) What are the customer_id, name and email of customers who have received only orders that were delivered by Karl?

Possible Marks: 20