Homework 1

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Question 1

a) $C(Model) = \Pi_{model}(\sigma_{city<50MPG}(Car))$

Question 1

b) $P(Model) = \Pi_{model}(\sigma_{towing \geq 12{,}500\ AND\ highway < 20MPG}\ (Pickup))$

Question 1

c)

$C1(maker) = \Pi_{maker}(\sigma_{MSRP<25,000}(Car \bowtie Product))$

$C2(Maker) = \Pi_{maker}(\sigma_{MSRP>60,000}(Car \bowtie Product))$

$P1(maker) = \Pi_{maker}(\sigma_{MSRP<25,000}(Pickup \bowtie Product))$

$P2(maker) = \Pi_{maker}(\sigma_{MSRP>60,000}(Pickup \bowtie Product))$

$E1(maker) = \Pi_{maker}(\sigma_{MSRP<25,000}(EV \bowtie Product))$

$2(maker) = \Pi_{maker}(\sigma_{MSRP>60,000}(EV \bowtie Product))$

$C3(Make) = (C1 \bowtie C2) \cup (C1 \bowtie P2) \cup (C1 \bowtie E2)$

$P3(Make) = (P1 \bowtie P2) \cup (P1 \bowtie C2) \cup (P1 \bowtie E2)$

$E3(Make) = (E1 \bowtie E2) \cup (E1 \bowtie C2) \cup (E1 \bowtie P2)$

$Answer(Make) = C3 \cup P3 \cup E3$

Question 1

d)

$$Car(MSRP) = \Pi_{MSRP}(\rho_{Car1}Car \bowtie_{Car1.model \neq Car2.model\ AND\ Car1.MSRP=Car2.MSRP}\ \rho_{Car2}Car)$$

$$Pickup(MSRP) = \Pi_{MSRP}(\rho_{P1}Pickup \bowtie_{P1.model \neq P2.model\ AND\ P1.MSRP=P2.MSRP}\ \rho_{P2}Pickup)$$

$$EV(MSRP) = \Pi_{MSRP}(\rho_{EV1}EV \bowtie_{EV1.model \neq EV2.model\ AND\ EV1.MSRP=EV2.MSRP}\ \rho_{EV2}EV)$$

$$CarPickup(MSRP) = \Pi_{MSRP}(Car \bowtie_{Car.MSRP=Pickup.MSRP}\ Pickup)$$

$$CarEV(MSRP) = \Pi_{MSRP}(Car \bowtie_{Car.MSRP=EV.MSRP}\ EV)$$

$$PickupEV(MSRP) = \Pi_{MSRP}(Pickup \bowtie_{Pickup.MSRP=EV.MSRP}\ EV)$$

$$Answer(MSRP) = Car \cup Pickup \cup EV \cup CarPickup \cup CarEV \cup PickupEV$$

Question 1

e)
$C(Model, Highway, City) = \rho_{Car1} Car \bowtie_{Car1.city*55+Car1.highway*45 > Car2.city*55+Car2.highway*45} \rho_{Car2} Car)$

$CMax(Model, Highway, City) = \Pi_{model,city,highway} Car - C$

$P(Model, Highway, City) = \rho_{P1} Pickup \bowtie_{(P1.city*55+P1.highway*45) > (P2.city*55+P2.highway*45)} \rho_{P2} Pickup)$

$PMax(Model, Highway, City) = \Pi_{model,city,highway} Pickup - P$

$Max1(Model) = CMax \bowtie_{CMax.city*55+CMax.highway*45 \geq PMax.city*55+PMax.highway*45} PMax$

$Max2(Model) = PMax \bowtie_{PMax.city*55+PMax.highway*45 \geq CMax.city*55+CMax.highway*45} PMax$

$Answer(Maker) = \Pi_{Maker}((Max1 \cup Max2) \bowtie_{Max1 \cup Max2.model = Product.model} Product)$

Question 1

f)

$C(model, city, highway) = \rho_{Car1}Car \bowtie_{Car1.city*55+Car1.highway*45>Car2.city*55+Car2.highway*45} \rho_{Car2}Car)$

$CMax(model, Highway, City) = \Pi_{model,city,highway}Car - C$

$P(model, Highway, City) = \rho_{P1}Pickup \bowtie_{(P1.city*55+P1.highway*45)>(P2.city*55+P2.highway*45)} \rho_{P2}Pickup)$

$PMax(Model, Highway, City) = \Pi_{model,city,highway}Pickup - P$

$Max1(Model) = CMax \bowtie_{CMax.city*55+CMax.highway*45 \geq PMax.city*55+PMax.highway*45} PMax$

$Max2(Model) = PMax \bowtie_{PMax.city*55+PMax.highway*45 \geq CMax.city*55+CMax.highway*45} PMax$

$CPMax(Model) = Max1 \cup Max2$

$E(model, battery, range) = \rho_{E1}EV \bowtie_{\frac{33.1*E1.range}{E1.battery} > \frac{33.1*E2.range}{E2.battery}} \rho_{E2}EV$

$EMax(Model, Highway, City) = \Pi_{model,battery,range}EV - E$

$Max3(Model) = CPMax \bowtie_{CPMax.city*55+CPMax.highway*45 \geq \frac{33.1*EMax.range}{EMax.battery}} EMax$

$$Max4(Model) = EMax \bowtie_{\frac{33.1*EMax.range}{EMax.battery} \geq CPMax.city*55+CPMax.highway*45} CPMax$$

Answer(maker)=$\Pi_{maker}((Max3 \cup Max4) \bowtie Product)$

Question 1

g)
$C(make) = \Pi_{maker}(\sigma_{city<15MPG}(Car \bowtie Product))$
$E(make) = \Pi_{maker}(EV \bowtie Product)$
$Answer = C \cup E$

Question 1

h)

CarMaker(maker)= $\Pi_{maker,trunk}(Car \bowtie Product)$

PickupMaker(maker)= $\rho_{Pickup'(maker,trunk)}(\Pi_{maker,cargo}(Pickup \bowtie Product))$

Vehicle(maker)=$CarMaker \cup PickupMaker$

TwoVehicles= $\rho_{V1}Vehicle \bowtie_{V1.maker=V2.maker\ AND\ V1.trunk \neq V2.trunk}\ \rho_{V2}Vehicle$

ThreeVehicles= $TwoVehicles \bowtie_{TwoVehicles.maker=V3.maker\ AND\ TwoVehicles.trunk \neq V3.trunk}\ \rho_{V3}Vehicle$

Answer(maker)=$\Pi_{Maker}ThreeVehicles$

Question 2

a)

$$\sigma_{towing<12{,}000}\ Pickup \subseteq \sigma_{MSRP<25{,}000}\ Pickup$$

Question 2

b)

$$EV \subseteq \sigma_{range>105} EV$$

Question 2

c)

$$\sigma_{city \geq 50MPG}\, Car \subseteq \sigma_{highway \geq 40MPG\, OR\, MSRP < 20{,}000}\, Car$$

Question 2

d)
$$\Pi_{maker}(Pickup \bowtie Product) \cap \Pi_{maker}(EV \bowtie Product) = \emptyset$$

Question 2

e)

$$\rho_{P1}Product \bowtie_{P1.model \neq P2.model\ AND\ P1.Maker=P2.Maker\ AND\ P2.Year=P2.Year} \rho_{P2}Product = \emptyset$$

Question 2

f)
$P(maker) = (\Pi_{maker}(Pickup \bowtie Product))$
$C(maker) = \Pi_{maker}((\Pi_{Car.model}(Pickup \bowtie_{Pickup.highway<Car.highway} Car)) \bowtie Product)$
$Answer = P \subseteq C$

Question 2

g)

$$Pickup \bowtie_{Pickup.city > Car.city \ AND \ Pickup.MSRP < 1.75 * Car.MSRP} Car = \emptyset$$

Question 3

a) We expect these Functional Dependencies to hold:

$ID \to P_xP_yP_zV_xV_yV_z$
$P_xP_yP_z \to ID$
$P_xP_yP_z \to V_x$
$P_xP_yP_z \to V_y$
$P_xP_yP_z \to V_z$
Or together, $P_xP_yP_z \to ID\,V_xV_yV_z$

We expect these Functional dependencies to hold true because if we have the position, we should be able to find the velocity or the ID, and with the ID, we should be able to find the position and velocity of the molecule.

Question 3

b) The keys are: P_x P_y P_z and ID since we can close all attributes given these keys.

Question 3

c) Potential SuperKeys:

-$\{P_xP_yP_zV_x\}$

-$\{ID\,V_x\}$

-$\{P_xP_yP_z\;ID\}$

These are SuperKeys since the key(s) are a subset of the superkey. An attribute can be deleted from the superkey and we can still map to all attributes.

Question 3

d) The superkeys can be found by looking at the powerset $\{P_xP_yP_zV_xV_yV_z\}$ for the key ID and the powerset $\{IDV_xV_yV_Z\}$ for the key $P_xP_yP_z$. So, there are a total of $(2^6-1)+(2^4-1) = 63+15 = 78$. Then, we must account for duplicates which occur when the superkey contains $P_x\ P_y\ P_z\ ID$. We can find this by finding P($\{P_xP_yP_zV_xV_yV_z\ ID\} - \{P_x\ P_y\ P_z\ ID\}) = 8$. So, the total should be 70 total superkeys.