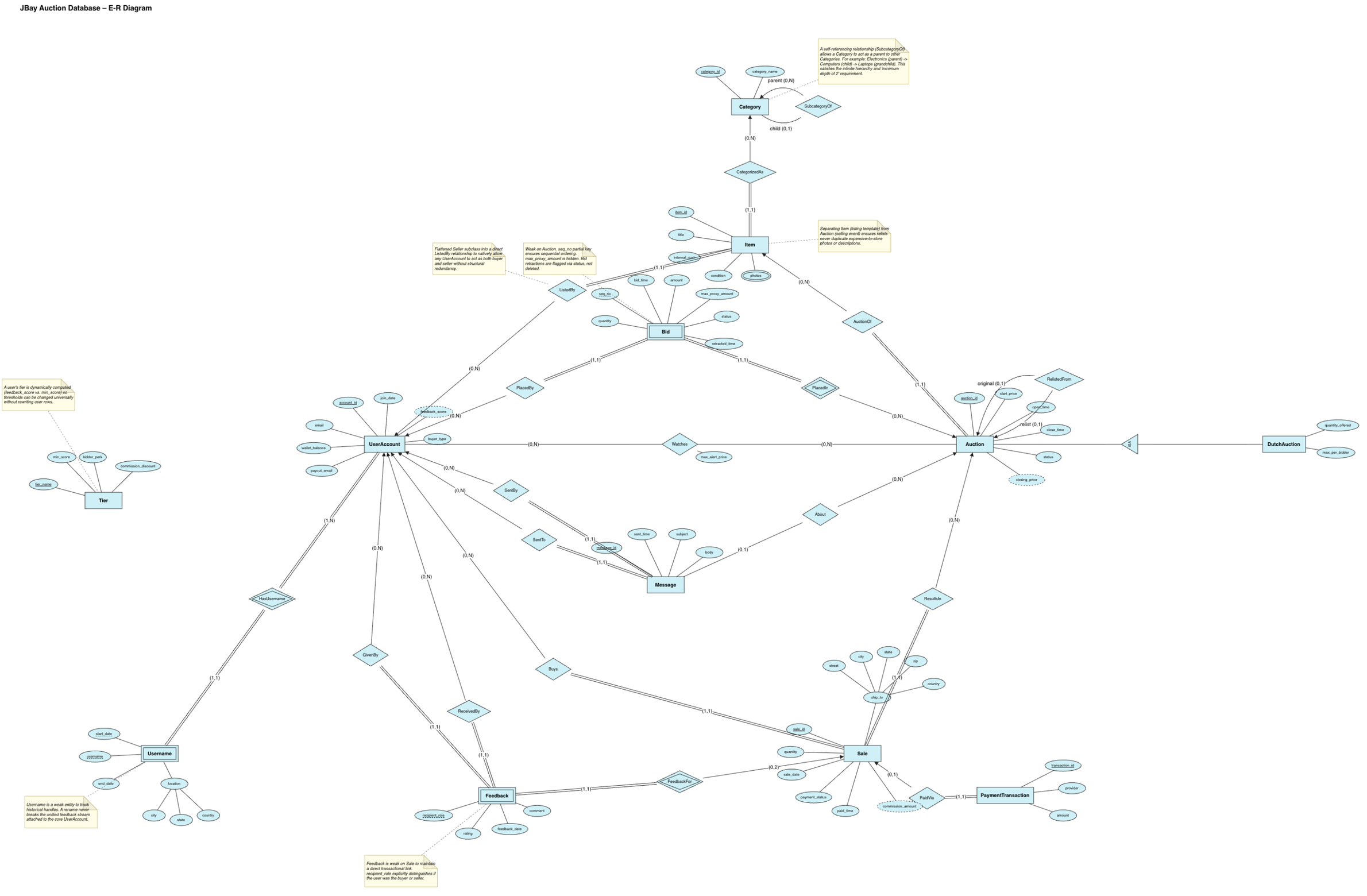
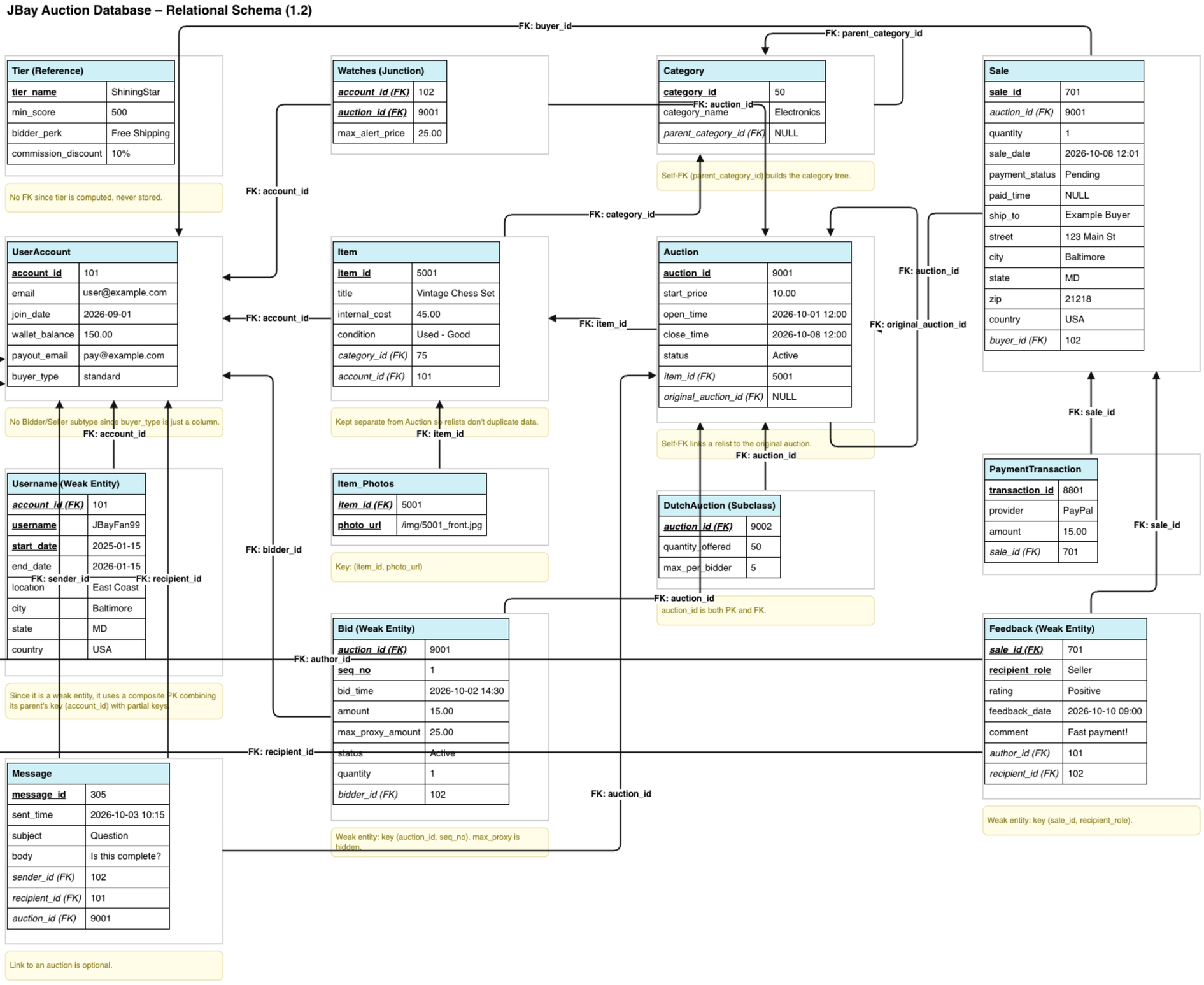
HW1a 1.1 Entity-relationship diagram



HW1a 1.2 Relational schema and example rows



HW1a 1.3

Relations used in the query solutions

This answer key presents one possible set of solutions. Other correct formulations are also valid. Questions 1.1-1.2 show one possible design. The formulas in 1.3 use the alternative relational representation defined below.

Relation	Attributes
Account	u, joined
Handle	u, since, until, name, city, country
Category	g, type, subtype
Item	i, g, label, description, unitCost
Auction	a, i, seller, prev, kind, qty, opens, closes, openPrice
Close	a, state, closePrice
Bid	a, seq, bidder, placed, amount, wantQty, proxyMax, retractedAt
Award	a, awardNo, seq, units, unitPrice, outcome
Watch	u, a, limitPrice
Feedback	f, a, writer, recipient, role, delta, body, sentAt

Keys and links. u, i, a and g identify an account, item, auction and category. Auction.seller and Bid.bidder are account keys. Bid is keyed by (a, seq). Award identifies its winning bid by (a, seq). Watch links an account to an auction.

Values and history. An open Handle.until identifies the current handle. Close records finalized auctions and their closing prices. Award.outcome records an allocation's status. Feedback.delta is -1, 0 or +1. Category.type and subtype give the two category levels; sequence numbers order bids within an auction.

Required questions by course

	601.315	601.415 / 615
HW1a	1.1, 1.2; 1.3(a,c,f)	1.1, 1.2; 1.3(d,f,i,k,r)
HW1b RA	2.1-2.25	2.18-2.47
HW1b TRC	2.2, 2.6, 2.19, 2.20	2.6-2.8, 2.19-2.22

Homework 1a 1.3

Queries on the JBay design

Use the relations above. Natural joins match identically named attributes. A rename $u \leftarrow \mathit{bidder}$ gives the bidder key its Account column name. γ groups by the attributes before the semicolon. Let H be current handles, U all accounts, and $N(v)$ the one-column set of account keys with current username v.

$$H \leftarrow \sigma_{\mathit{until}\ \text{is open}}(\mathit{Handle}), \quad U \leftarrow \pi_u(\mathit{Account}), \quad N(v) \leftarrow \pi_u(\sigma_{\mathit{name}=v}(H)).$$
$$D \leftarrow \pi_{u \leftarrow \mathit{bidder},a}(\mathit{Bid}), \qquad J \leftarrow \pi_u(D).$$

1.3(a) Low feedback among recent members

$$S \leftarrow \gamma_{\mathit{recipient}\,;\,\mathrm{sum}(\mathit{delta})\rightarrow\mathit{score}}(\mathit{Feedback})$$
$$F \leftarrow \pi_{u \leftarrow \mathit{recipient}}(\sigma_{\mathit{score}<-20}(S))$$
$$\mathit{Ans} \leftarrow \pi_{\mathit{name}}(H \bowtie F \bowtie \sigma_{\mathit{joined}\geq\text{'2026-07-01'}}(\mathit{Account})).$$

An account with zero received feedback cannot meet the strict threshold.

1.3(c) Watched, finished, and never bid on

$$W \leftarrow \pi_a(\mathit{Watch} \bowtie N(\text{'ImTooTimid'})), \qquad Z \leftarrow \pi_a(\mathit{Close}) - \pi_a(\mathit{Bid})$$
$$\mathit{Ans} \leftarrow \pi_{i,\mathit{label}}((W \cap Z) \bowtie \mathit{Auction} \bowtie \mathit{Item}).$$

An auction with no bids from anyone automatically has none from the watcher. Relists stay separate until the final item projection.

1.3(d) Outcomes for auctions on which jjcool bid

$$T \leftarrow \pi_a(\sigma_{\mathit{placed}\geq\text{'2025-12-31'}}(\mathit{Bid}) \bowtie_{\mathit{bidder}=u} N(\text{'jjcool'}))$$
$$I \leftarrow \pi_{a,\mathit{label},\mathit{type}}(T \bowtie \mathit{Auction} \bowtie \mathit{Item} \bowtie \mathit{Category})$$
$$G \leftarrow \pi_{a,\mathit{winner}\leftarrow\mathit{name}}(\sigma_{\mathit{outcome}\neq\text{'refused'}}(\mathit{Award}) \bowtie \mathit{Bid} \bowtie_{\mathit{bidder}=u} H)$$
$$\mathit{Ans} \leftarrow \pi_{\mathit{label},\mathit{type},\mathit{closePrice},\mathit{winner}}((I \ \text{ left join } \ \pi_{a,\mathit{closePrice}}(\mathit{Close})) \ \text{ left join } \ G).$$

The left joins use a. They retain a qualifying auction before a price or winner exists. Each Dutch winner contributes a row.

1.3(f) Bidders covering every IlikePonies auction

$$T \leftarrow \pi_a(\mathit{Auction} \bowtie_{\mathit{seller}=u} N(\text{'IlikePonies'}))$$
$$\mathit{Good} \leftarrow J - \pi_u((J \times T) - D), \qquad \mathit{Ans} \leftarrow \pi_{\mathit{name}}(H \bowtie \mathit{Good}).$$

The candidate set J contains people who have actually bid. If the seller has held no auctions, every such bidder qualifies.

Homework 1a 1.3 continued

Bid history, private prices and exclusions

1.3(i) Users who followed MileyC with a higher bid in every relevant auction

Let m and b denote separate copies of the bid relation; a qualified field refers to the indicated copy. Sequence numbers order bids within an auction.

$$M \leftarrow \rho_m(Bid \bowtie_{bidder=u} N(\text{'MileyC'}))\,, \qquad B' \leftarrow \rho_b(Bid)$$
$$T \leftarrow \pi_{a \leftarrow m.a}(M)\,, \quad C \leftarrow U - N(\text{'MileyC'})$$
$$P \leftarrow \pi_{u \leftarrow b.bidder,\, a \leftarrow b.a}\left(B' \bowtie_{\substack{b.a=m.a,\ b.seq>m.seq \\ b.amount>m.amount,\ b.bidder \neq m.bidder}} M\right)$$
$$Good \leftarrow C - \pi_u((C \times T) - P)\,, \qquad Ans \leftarrow \pi_{name,city,country}(H \bowtie Good)\,.$$

One later, higher bid suffices for each of her auctions. A higher bid on only one of several auctions does not suffice. This reading compares other users with MileyC.

1.3(k) Completed auctions outside ICantStop's proxy range

$$P \leftarrow \sigma_{proxyMax \text{ is present}}(Bid) \bowtie_{bidder=u} N(\text{'ICantStop'})$$
$$M \leftarrow \gamma_{a\,;\,\max(proxyMax) \rightarrow hi}(P)$$
$$Ans \leftarrow \pi_a\Big(\sigma_{closePrice<hi/2 \ \vee \ closePrice>2hi}(M \bowtie Close)\Big)\,.$$

Use this bidder's highest hidden limit for each auction and its recorded closing price. Both comparisons are strict.

1.3(r) Users with no bids in the excluded categories

$$F \leftarrow \sigma_{(type=\text{'Collectibles'} \wedge subtype=\text{'BeanieBabies'}) \ \vee \ type=\text{'VideoGame'}}(Category)$$
$$Bad \leftarrow \pi_{u \leftarrow bidder}(Bid \bowtie Auction \bowtie Item \bowtie F)$$
$$IDs \leftarrow U - Bad, \qquad Ans \leftarrow \pi_{userID \leftarrow name}(H \bowtie IDs)\,.$$

The output shows current public user IDs. IDs gives their stable internal keys. The two-level Category table gives every subtype a top-level type. Every VideoGame subtype therefore matches the second condition. A user with no bids belongs in the result.

Homework 1b

Library relations and notation

Aliases below rename attributes positionally in the order printed in the handout. This makes every unqualified natural join in the answers a join on its intended keys. For example, the borrower's home city is *home* and the branch's city is *city*.

Relation	Alias	Renamed attributes
BOOK	B	$b, title, p$
PUBLISHER	P	$p, pCity, country$
BOOK AUTHORS	A	$b, author$
BOOK COPIES	C	b, h, n
BOOK LOANS	L	b, h, c, out, due
BORROWER	U	$c, name, address, home$
LIBRARY BRANCH	H	$h, branch, addr, city, hPhone$
LIBRARY STAFF	S	$e, h, staff, pos, sPhone$
BOOK REVIEWS	V	$r, b, c, rating, body$
NEW BOOK WISHLIST	W	b, c
LIBRARY COMPUTER	K	$k, h, loc, os, status$
COMPUTER RESERVATION	X	$k, c, day, start, end$
MEETING ROOM	M	$m, h, cap, kind$
ROOM RESERVATION	Y	$m, c, day, start, end$
LIBRARY EVENTS	E	$ev, h, e, c, eventTitle$

b, h and c respectively identify a book, a branch and a borrower card. Variables n, r, k and m denote copy count, review ID, computer ID and room ID. Projections use set semantics; differences match the indicated columns by name. Each answer's local variables have scope within that answer.

Shared notation **Selections and set operations**

CV and TS stand for the branch names Charles Village and Towson South. Kim and Steve stand for Kim Kardashian and Steve Bannon. Publicity abbreviates the title *How to Avoid Publicity*; Fences abbreviates *How to Mend Fences with your Family.*

$$U_c = \pi_c(U)\,, \quad B_b = \pi_b(B)\,, \quad H_h = \pi_h(H)\,, \quad O = \sigma_{n>0}(C)$$
$$H_z = \pi_h(\sigma_{branch=z}(H))\,, \quad L_{cb} = \pi_{c,b}(L)\,, \quad V_{cb} = \pi_{c,b}(V)\,, \quad W_{cb} = \pi_{c,b}(W)\,.$$

For unary candidate keys $F(x)$ and targets $T(y)$ and observed pairs $Z(x, y)$, define

$$\mathrm{Cover}(F, T, Z) = F - \pi_x\big((F \times T) - Z\big).$$

It retains the candidates paired with every target, including all candidates if the target set is empty. For scored rows $G(x, n)$, $\mathrm{Top}(G)$ keeps all rows for which no row of G has a strictly larger n, equivalently $G \bowtie_{n=m} \gamma_{\max(n)\to m}(G)$. The result can be projected onto x, n. We use γ for grouping and aggregation; $\pi_{new\leftarrow old}$ renames a projected column.

HW1b Relational algebra

2.1–2.6 Borrowers, reviews and staff

2.1 Titles and ratings reviewed by Kim Kardashian

$$Ans = \pi_{title,rating}(\sigma_{name=\mathsf{Kim}}(U) \bowtie V \bowtie B)\,.$$

The name identifies the reviewer.

2.2 Staff working in the same city as Kim Kardashian

$$Cities \leftarrow \pi_{home}(\sigma_{name=\mathsf{Kim}}(U))\,, \qquad Branches \leftarrow \pi_{h}(H \bowtie_{city=home} Cities)$$
$$Ans \leftarrow \pi_{staff,pos}(S \bowtie Branches)\,.$$

2.3 A wished-for book neither borrowed nor reviewed by its wisher

$$Unused \leftarrow W_{cb} - (L_{cb} \cup V_{cb}), \quad Ans \leftarrow \pi_{name,c}(U \bowtie Unused)\,.$$

Test the borrower–book pair before returning the borrower.

2.4 Mac reservations by a borrower with a loan

$$Mac \leftarrow X \bowtie \sigma_{os='\mathrm{macOS}'}(K)\,, \quad Ans \leftarrow \pi_{name,k,branch}(U \bowtie \pi_{c}(L) \bowtie Mac \bowtie H)\,.$$

Under the course clarification, any loan row for the borrower suffices, regardless of its dates or branch.

2.5 Review of a book the reviewer never borrowed

$$Ans = \pi_{c,name}(U \bowtie (V_{cb} - L_{cb}))\,.$$

A loan of another book does not disqualify the borrower.

2.6 Staff at any branch where Steve Bannon borrowed

$$Sites \leftarrow \pi_{h}(\sigma_{name=\mathsf{Steve}}(U) \bowtie L)\,, \quad Ans \leftarrow \pi_{staff,pos,sPhone}(S \bowtie Sites)\,.$$

HW1b Relational algebra

2.7–2.12 Matching people, dates and books

2.7 Individual rooms at both named branches on the same day

$$R \leftarrow Y \bowtie \sigma_{kind=\text{'Individual'}}(M)\,, \quad D_z \leftarrow \pi_{c,day}(R \bowtie H_z)$$
$$Ans \leftarrow \pi_{name}(U \bowtie (D_{\mathsf{CV}} \cap D_{\mathsf{TS}}))\,.$$

BORROWER has no phone column. Return the available name; both the card and the reservation date must match.

2.8 Reviews of more than one distinct book

$$G \leftarrow \gamma_{c\,;\,\text{count}(b)\to n}(V_{cb})\,, \quad Ans \leftarrow \pi_{name}(U \bowtie \sigma_{n>1}(G))\,.$$

2.9 A borrower who has borrowed a book on their wishlist

$$Ans = \pi_{name}(U \bowtie (W_{cb} \cap L_{cb}))\,.$$

2.10 Borrowers and books associated with low ratings

$$Ans = \pi_{c,name,title,rating}(U \bowtie \sigma_{rating=1 \vee rating=2}(V) \bowtie B)\,.$$

2.11 Staff at a branch owning a wished-for book

$$Sites \leftarrow \pi_h(O \bowtie \pi_b(W))\,, \quad Ans \leftarrow \pi_{e,staff,branch}(S \bowtie Sites \bowtie H)\,.$$

Use positive holdings; a row with zero copies still exists in BOOK COPIES.

2.12 Borrowers covering the Charles Village collection

$$T \leftarrow \pi_b(O \bowtie H_{\mathsf{CV}})\,, \quad Good \leftarrow \text{Cover}(U_c, T, L_{cb}), \quad Ans \leftarrow \pi_{c,name}(U \bowtie Good)\,.$$

Here the branch defines the target collection; borrowing a target book from any branch counts. For the reading requiring local checkouts, replace L_{cb} with $\pi_{c,b}(L \bowtie H_{\mathsf{CV}})$.

HW1b Relational algebra

2.13–2.18 Branch holdings and coverage

2.13 More dishwashing books than copies of Brave New World

$$\begin{aligned} D &\leftarrow \pi_{h,n_D \leftarrow n}(C \bowtie \sigma_{title=\text{'Dishwashing for Dummies'}}(B)) \\ N &\leftarrow \pi_{h,n_N \leftarrow n}(C \bowtie \sigma_{title=\text{'Brave New World'}}(B)) \\ Ans &\leftarrow \pi_{branch,addr}(H \bowtie \sigma_{n_D > n_N}(D \bowtie N)) \,. \end{aligned}$$

The handout permits one book ID for each of these two titles.

2.14 Books with at least two authors

$$G \leftarrow \gamma_{b\,;\,\text{count}(author)\rightarrow j}(\pi_{b,author}(A)) \,, \quad Ans \leftarrow \pi_{title,p}(B \bowtie \sigma_{j>1}(G)) \,.$$

2.15 In Charles Village but absent from Towson South

$$Ans = \pi_{title,p}(B \bowtie (\pi_b(O \bowtie H_{\mathsf{CV}}) - \pi_b(O \bowtie H_{\mathsf{TS}}))) \,.$$

2.16 Borrowers with no loan from their home city

$$Local \leftarrow \pi_c(\sigma_{home=city}(U \bowtie L \bowtie H)) \,, \quad Ans \leftarrow \pi_{name,address,c}(U \bowtie (U_c - Local)) \,.$$

This includes a borrower with no loans.

2.17 Borrowers who have used every branch

$$Ans = \pi_{name,address,c}(U \bowtie \text{Cover}(U_c, H_h, \pi_{c,h}(L))) \,.$$

2.18 Branches holding no copies of How to Avoid Publicity

$$Has \leftarrow \pi_h(O \bowtie \sigma_{title=\mathsf{Publicity}}(B)) \,, \quad Ans \leftarrow \pi_{branch,city}(H \bowtie (H_h - Has)) \,.$$

Subtract at the branch-ID level before projecting its name and city.

HW1b Relational algebra

2.19–2.24 Copies, loans and reservations

2.19 Staff at branches holding at least 100 copies

$$Ans = \pi_{staff,pos}(S \bowtie \pi_h(\sigma_{n \geq 100}(C) \bowtie \sigma_{title=\mathsf{Publicity}}(B))) .$$

2.20 Books never borrowed by a Towson resident

$$T \leftarrow \pi_b(L \bowtie \sigma_{home='\mathrm{Towson}'}(U)) , \quad Ans \leftarrow \pi_{title,p}(B \bowtie (B_b - T)) .$$

2.21 Baltimore loans due October 1, 2026

$$D \leftarrow \sigma_{due='2026\text{-}10\text{-}01'}(L) \bowtie \pi_h(\sigma_{city='\mathrm{Baltimore}'}(H))$$
$$Ans \leftarrow \pi_{title,author,name,address}(D \bowtie B \bowtie A \bowtie U) .$$

The loan column is DateDue. PUBLISHER provides City and Country but has no Address. The address in the result is the borrower's.

2.22 More copies than the Fences book at Charles Village

$$C_V \leftarrow C \bowtie H_{\mathsf{CV}}, \qquad Ref \leftarrow \pi_{h,n_0 \leftarrow n}(C_V \bowtie \sigma_{title=\mathsf{Fences}}(B))$$
$$More \leftarrow \pi_b(\sigma_{n>n_0}(C_V \bowtie Ref)) , \quad Ans \leftarrow \pi_{title,author,p,country}(More \bowtie B \bowtie A \bowtie P) .$$

The count comparison uses the same branch on both sides.

2.23 Charles Village Mac reservation plus another branch that day

$$G \leftarrow X \bowtie K, \quad F \leftarrow \rho_f(\sigma_{os='\mathrm{macOS}'}(G) \bowtie H_{\mathsf{CV}}) , \quad D \leftarrow \rho_d(G)$$
$$T \leftarrow F \bowtie_{f.c=d.c \,\wedge\, f.day=d.day \,\wedge\, f.h \neq d.h} D$$
$$Ans \leftarrow \pi_{name,k \leftarrow f.k,start \leftarrow f.start}(U \bowtie_{c=f.c} T) .$$

The second reservation can use any operating system. Return the computer and start time of the Charles Village reservation.

2.24 Wishlisted by two or more distinct borrowers

$$G = \gamma_{b\,;\,\mathrm{count}(c) \to j}(W_{cb}) , \qquad Ans = \pi_{title,j}(B \bowtie \sigma_{j \geq 2}(G)) .$$

Project to distinct card/book pairs before counting. In the printed wishlist, the duplicated entry for card 65771 contributes once. The result is (The Art of the Deal, 2).

HW1b Relational algebra

2.25–2.29 Recommendations and comparisons

2.25 Open question: a recommendation the borrower can actually find

For each borrower, recommend an unread, unreviewed book on their wishlist that is stocked at *every* branch where they have booked a group room with capacity over 10. Require at least one such booking. Return card number, borrower name and title. Here unread means no recorded checkout.

$$
\begin{aligned}
D &\leftarrow W_{cb} - (L_{cb} \cup V_{cb}) \\
G &\leftarrow \pi_{c,h}(Y \bowtie \sigma_{kind=\text{'Group'} \wedge cap>10}(M)) \\
Need &\leftarrow \pi_{c,b,h}(D \bowtie G)\,, \qquad Stock \leftarrow \pi_{b,h}(O) \\
Good &\leftarrow \pi_{c,b}(Need) - \pi_{c,b}(Need - (Need \bowtie Stock)) \\
Ans &\leftarrow \pi_{c,name,title}(U \bowtie Good \bowtie B)\,.
\end{aligned}
$$

Each needed triple links a candidate, a book and a branch relevant to that borrower. A single missing branch disqualifies the recommendation. This is one example for the open question.

2.26 Copies of How to Avoid Publicity at each branch

$$
\begin{aligned}
T &\leftarrow \gamma_{h\,;\,\text{sum}(n)\to total}(C \bowtie \sigma_{title=\text{Publicity}}(B)) \\
G &\leftarrow T \cup \pi_{h,\,total\leftarrow 0}(H_h - \pi_h(T))\,, \qquad Ans \leftarrow \pi_{branch,total}(H \bowtie G)\,.
\end{aligned}
$$

Keeping all branch IDs also gives zero if the title is absent from the catalog.

2.27 Books with more than two authors

$$
G = \gamma_{b\,;\,\text{count}(author)\to j}(\pi_{b,author}(A))\,, \quad Ans = \pi_{title,p}(B \bowtie \sigma_{j>2}(G))\,.
$$

2.28 In Baltimore and unavailable at some Towson or Columbia branch

$$
\begin{aligned}
D &\leftarrow \pi_h(\sigma_{city=\text{'Towson'} \vee city=\text{'Columbia'}}(H)) \\
I &\leftarrow \pi_b(O \bowtie \sigma_{city=\text{'Baltimore'}}(H))\,, \qquad Z \leftarrow \pi_b(\sigma_{n=0}(C) \bowtie D) \\
Ans &\leftarrow \pi_{title,p}(B \bowtie (I \cap Z))\,.
\end{aligned}
$$

This uses the literal *some branch* reading. Under the stronger *unavailable at every such branch* reading, use $I - \pi_b(O \bowtie D)$ in place of $I \cap Z$.

2.29 Authors borrowing a same-name author's book

$$
\begin{aligned}
I &\leftarrow \pi_{c,name}(U \bowtie_{name=author} \pi_{author}(A)) \\
Y^+ &\leftarrow \pi_c(\sigma_{name=author}(U \bowtie L \bowtie A)) \\
Ans_{\text{no}} &\leftarrow \pi_{name}\Big(I \bowtie (\pi_c(I) - Y^+)\Big)\,, \qquad Ans_{\text{yes}} \leftarrow \pi_{name}\Big(I \bowtie Y^+\Big)\,.
\end{aligned}
$$

Test each borrower by card before projecting their name. Two people with the same name can have different histories. Both polarities are accepted for 2.29 and 2.33.

HW1b Relational algebra

2.30–2.35 Branch collections and extrema

2.30 Borrowers covering at least one branch's whole collection

$$\begin{aligned} Pairs &\leftarrow U_c \times H_h, \qquad Need \leftarrow U_c \times \pi_{h,b}(O) \\ Miss &\leftarrow \pi_{c,h}(Need - (Need \bowtie L_{cb})) \\ Good &\leftarrow \pi_c(Pairs - Miss)\,, \qquad Ans \leftarrow \pi_{c,name}(U \bowtie Good)\,. \end{aligned}$$

The branch is chosen separately for each borrower. Here checkout at any branch counts for the target book. To require checkout at the selected branch, use $Need \bowtie \pi_{c,h,b}(L)$ as the observed triples. A branch with no positive holdings has an empty collection.

2.31 Borrowed by a Baltimore resident and never by a Towson resident

$$D_z = \pi_b(L \bowtie \sigma_{home=z}(U))\,, \qquad Ans = \pi_{title,p}(B \bowtie (D_{\text{'Baltimore'}} - D_{\text{'Towson'}}))\,.$$

2.32 Books with positive stock at every branch

$$Ans = \pi_{title}(B \bowtie \mathrm{Cover}(B_b, H_h, \pi_{b,h}(O)))\,.$$

2.33 Repeated same-name author question

With I and Y^+ from 2.29, either $\pi_{name}(I \bowtie (\pi_c(I) - Y^+))$ or $\pi_{name}(I \bowtie Y^+)$ is accepted. The same interpretation may be used for both questions.

2.34 Books with the highest stock at Charles Village, including ties

$$\begin{aligned} D &\leftarrow \pi_{b,n}(C \bowtie H_{\mathsf{CV}})\,, \qquad T \leftarrow \pi_b(\mathrm{Top}(D)) \\ Ans &\leftarrow \pi_{title,author,p,country}(T \bowtie B \bowtie A \bowtie P)\,. \end{aligned}$$

The maximum is computed inside the named branch. All authors of every tied book are reported.

2.35 Books both written and reviewed by Kim Kardashian

$$Ans = \pi_{title,rating}(B \bowtie \sigma_{author=\mathsf{Kim}}(A) \bowtie V \bowtie \sigma_{name=\mathsf{Kim}}(U))\,.$$

The author and reviewer filters meet on the same book ID.

HW1b Relational algebra

2.36–2.40 Grouping and correlated coverage

2.36 Shared wishlist book reviewed by one of its wishers

$$G \leftarrow \gamma_{b\,;\,\mathrm{count}(c)\to j}(W_{cb})\,, \quad Popular \leftarrow \pi_b(\sigma_{j\geq 2}(G))\,, \quad Reviewed \leftarrow \pi_b(W_{cb} \cap V_{cb})$$
$$Ans \leftarrow \pi_{title}(B \bowtie (Popular \cap Reviewed))\,.$$

2.37 Available Mac reserved by a borrower with a wishlist

$$Ans = \pi_{branch}(H \bowtie \sigma_{os=\text{'macOS'} \wedge status=\text{'Available'}}(K) \bowtie X \bowtie \pi_c(W))\,.$$

2.38 All borrowers tied for the largest number of checkouts

$$T \leftarrow \gamma_{c\,;\,\mathrm{count}(b)\to n}(L)\,, \qquad G \leftarrow T \cup \pi_{c,n\leftarrow 0}(U_c - \pi_c(T))$$
$$Ans \leftarrow \pi_{name,c}(U \bowtie \pi_c(\mathrm{Top}(G)))\,.$$

Each loan tuple counts once, including a repeat checkout. For a distinct-book reading, aggregate L_{cb} instead. With no loans, all borrowers tie at zero.

2.39 Borrowers who reviewed every book they borrowed

$$Ans = \pi_{c,name}(U \bowtie (U_c - \pi_c(L_{cb} - V_{cb})))\,.$$

A borrower with no loans has no missing review.

2.40 Manager event and large group room at every London branch

$$Hosts \leftarrow \pi_e(\sigma_{pos=\text{'Manager'}}(S))\,, \qquad F \leftarrow \pi_c(E \bowtie Hosts)$$
$$London \leftarrow \pi_h(\sigma_{city=\text{'London'}}(H))\,, \qquad G \leftarrow \pi_{c,h}(Y \bowtie \sigma_{kind=\text{'Group'} \wedge cap>10}(M))$$
$$Ans \leftarrow \pi_{c,name}(U \bowtie \mathrm{Cover}(F, London, G))\,.$$

The event may occur anywhere. A London branch without a qualifying room prevents every candidate from meeting the room condition. If there are no London branches, only attendance at a manager's event is required.

HW1b Relational algebra

2.41–2.47 Universal conditions and ties

2.41 Wishlists containing every book by Kim Kardashian

$$T = \pi_b(\sigma_{author=\mathsf{Kim}}(A)), \qquad Ans = \pi_{name,c}(U \bowtie \mathrm{Cover}(U_c, T, W_{cb})).$$

2.42 Staff at branches that loaned books from every publisher

$$T \leftarrow \pi_p(P), \qquad Z \leftarrow \pi_{h,p}(L \bowtie B), \quad Ans \leftarrow \pi_{staff}(S \bowtie \mathrm{Cover}(H_h, T, Z)).$$

The publisher universe here is PUBLISHER. If the intended universe is publishers represented by a catalog book, use $\pi_p(B)$ as the target.

2.43 All borrowers tied for most reviews

$$T \leftarrow \gamma_{c\,;\,\mathrm{count}(r)\to n}(V), \qquad G \leftarrow T \cup \pi_{c,n\leftarrow 0}(U_c - \pi_c(T))$$
$$Ans \leftarrow \pi_{c,name}(U \bowtie \pi_c(\mathrm{Top}(G))).$$

Count review IDs, so several reviews of the same book contribute separately.

2.44 Books reviewed by everyone who borrowed them

$$Ans = \pi_{b,title}(B \bowtie (B_b - \pi_b(L_{cb} - V_{cb}))).$$

Starting from the catalog includes a book no one has checked out.

2.45 Study-room reservations at every branch offering one

$$T = \pi_h(M), \qquad Z = \pi_{c,h}(Y \bowtie M), \qquad Ans = \pi_{c,name}(U \bowtie \mathrm{Cover}(U_c, T, Z)).$$

We treat each MEETING ROOM as a study room. The handout defines no separate study-room category.

2.46 Nonempty wishlist and a review for each wished-for book

$$Ans = \pi_{c,name}(U \bowtie (\pi_c(W) - \pi_c(W_{cb} - V_{cb}))).$$

The starting set $\pi_c(W)$ enforces the explicit nonempty-wishlist requirement.

2.47 Highest rating per reviewed book, including tied reviewers

$$G \leftarrow \gamma_{b\,;\,\max(rating)\to hi}(V), \quad T \leftarrow \sigma_{rating=hi}(V \bowtie G)$$
$$Ans \leftarrow \pi_{title,c,name,rating}(B \bowtie T \bowtie U).$$

HW1b Tuple relational calculus

2.2, 2.6, 2.7 and 2.8

Each expression returns a set of output tuples t. A quantifier such as $\exists s \in S$ ranges over an actual tuple in the named relation. Fields use the same aliases as the RA answers. The order of values inside $\langle \cdots \rangle$ is the output column order.

2.2 Staff in a Kim Kardashian borrower's home city

$$\{t \mid \exists s \in S\, \exists h \in H\, \exists u \in U\ (\\ u.name = \mathsf{Kim}\ \wedge\ s.h = h.h\ \wedge\ h.city = u.home \\ \wedge\, t = \langle s.staff, s.pos \rangle)\}.$$

2.6 Staff at branches used by Steve Bannon

$$\{t \mid \exists s \in S\, \exists l \in L\, \exists u \in U\ (\\ u.name = \mathsf{Steve}\ \wedge\ l.c = u.c\ \wedge\ s.h = l.h \\ \wedge\, t = \langle s.staff, s.pos, s.sPhone \rangle)\}.$$

2.7 Individual room at each branch on the same date

For a reservation tuple y, write the following bounded predicate.

$$I(y, z) \iff \exists m \in M\, \exists h \in H\ (m.m = y.m \wedge m.h = h.h \wedge m.kind = \text{'Individual'} \wedge h.branch = z).$$

$$\{t \mid \exists u \in U\, \exists y_1 \in Y\, \exists y_2 \in Y\ (\\ y_1.c = u.c \wedge y_2.c = u.c \wedge y_1.day = y_2.day \\ \wedge\, I(y_1, \mathsf{CV}) \wedge I(y_2, \mathsf{TS}) \wedge t = \langle u.name \rangle)\}.$$

The borrower's phone is unavailable. Start times need not match.

2.8 At least two distinct books reviewed

$$\{t \mid \exists u \in U\, \exists v_1 \in V\, \exists v_2 \in V\ (\\ v_1.c = u.c \wedge v_2.c = u.c \wedge v_1.b \neq v_2.b \wedge t = \langle u.name \rangle)\}.$$

HW1b Tuple relational calculus

2.19–2.22 Loans and holdings

2.19 Staff at branches holding at least 100 copies of the named book

$$\{t \mid \exists s \in S\, \exists x \in C\, \exists b \in B\ (\\ s.h = x.h \wedge x.b = b.b \wedge b.title = \mathsf{Publicity} \wedge x.n \geq 100 \\ \wedge\, t = \langle s.staff, s.pos \rangle)\}.$$

2.20 Books never borrowed by a Towson resident

$$\{t \mid \exists b \in B\ (t = \langle b.title, b.p \rangle \\ \wedge \neg \exists l \in L\, \exists u \in U\ (l.b = b.b \wedge l.c = u.c \wedge u.home = \text{'Towson'}))\}.$$

The negated witness is a loan of the *candidate book* to a Towson resident.

2.21 Baltimore loans due October 1, 2026

$$\{t \mid \exists l \in L\, \exists h \in H\, \exists b \in B\, \exists w \in A\, \exists u \in U\ (\\ l.h = h.h \wedge h.city = \text{'Baltimore'} \wedge l.due = \text{'2026-10-01'} \\ \wedge\, l.b = b.b \wedge w.b = b.b \wedge l.c = u.c \\ \wedge\, t = \langle b.title, w.author, u.name, u.address \rangle)\}.$$

PUBLISHER has no Address. The available requested fields identify the book and author, and the borrower's name and address.

2.22 Copies at Charles Village compared with the reference book

$$\{t \mid \exists h \in H\, \exists x \in C\, \exists x_0 \in C\, \exists b \in B\, \exists b_0 \in B \\ \exists w \in A\, \exists p \in P\ (h.branch = \mathsf{CV} \wedge x.h = h.h \wedge x_0.h = h.h \\ \wedge\, b_0.title = \mathsf{Fences} \wedge x_0.b = b_0.b \wedge x.b = b.b \wedge x.n > x_0.n \\ \wedge\, w.b = b.b \wedge p.p = b.p \\ \wedge\, t = \langle b.title, w.author, b.p, p.country \rangle)\}.$$