Return IDs and dates of all the applications where major is 'CSC'

$$\pi_{ID,\ date}\left(\sigma_{major = 'CSC'}(Apply)\right)$$

Cross product: $R \times S$

- schema of output: concatenation of the input schemas, with renaming of duplicate attributes ('R.A' will always work for A)

R: A B

R: R.A R.B

R: ↙ n

A	B
1	2
3	4

S: ↙ m

B	C	D
2	5	6
4	7	8
9	10	11

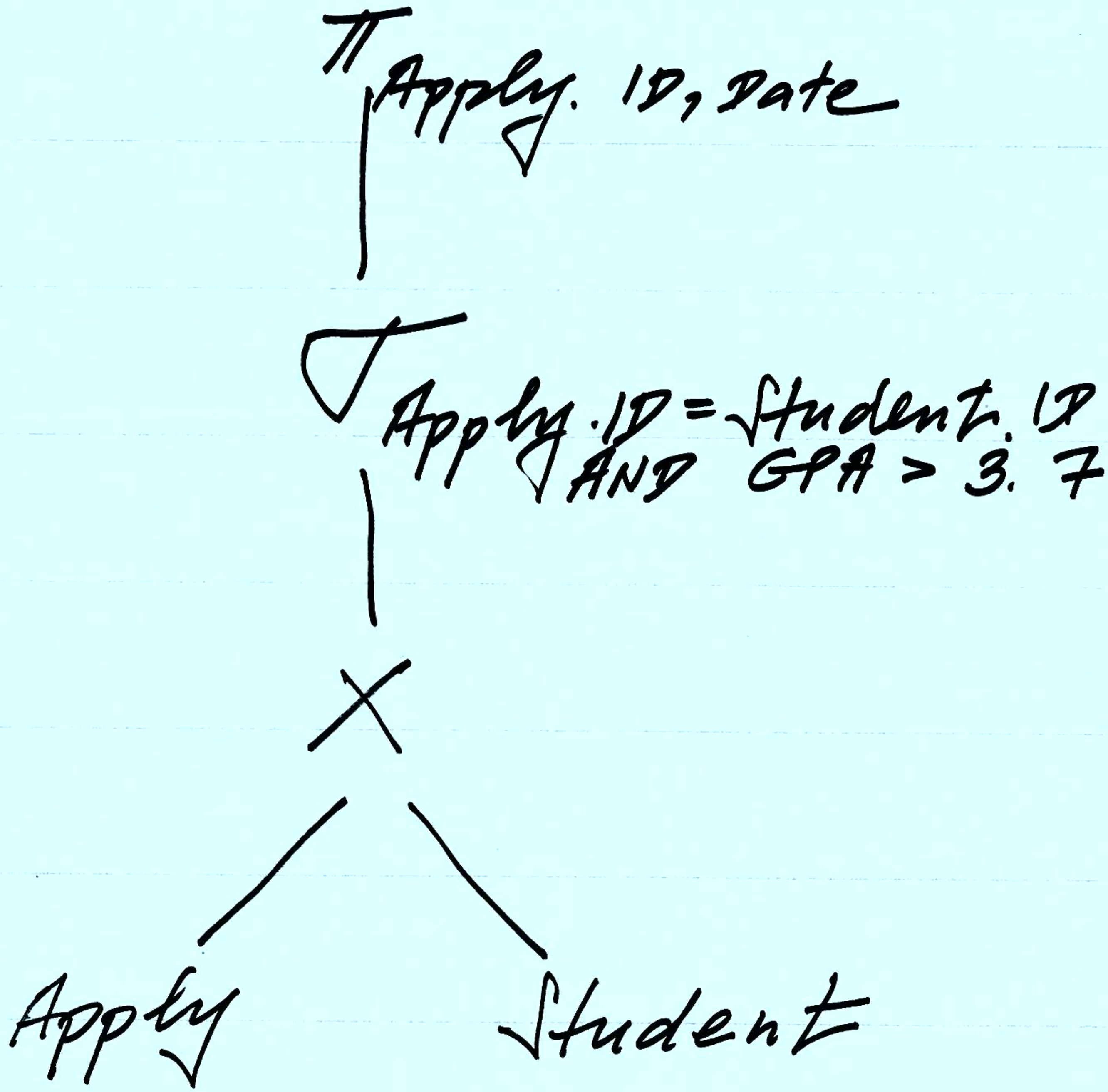
R × S

A	R.B	S.B	C	D	(E
1	2	2	5	6	—
1	2	4	7	8	—
1	2	9	10	11	✓
3	4	2	5	6	✓
3	4	4	7	8	—
3	4	9	10	11	✓

Q1:

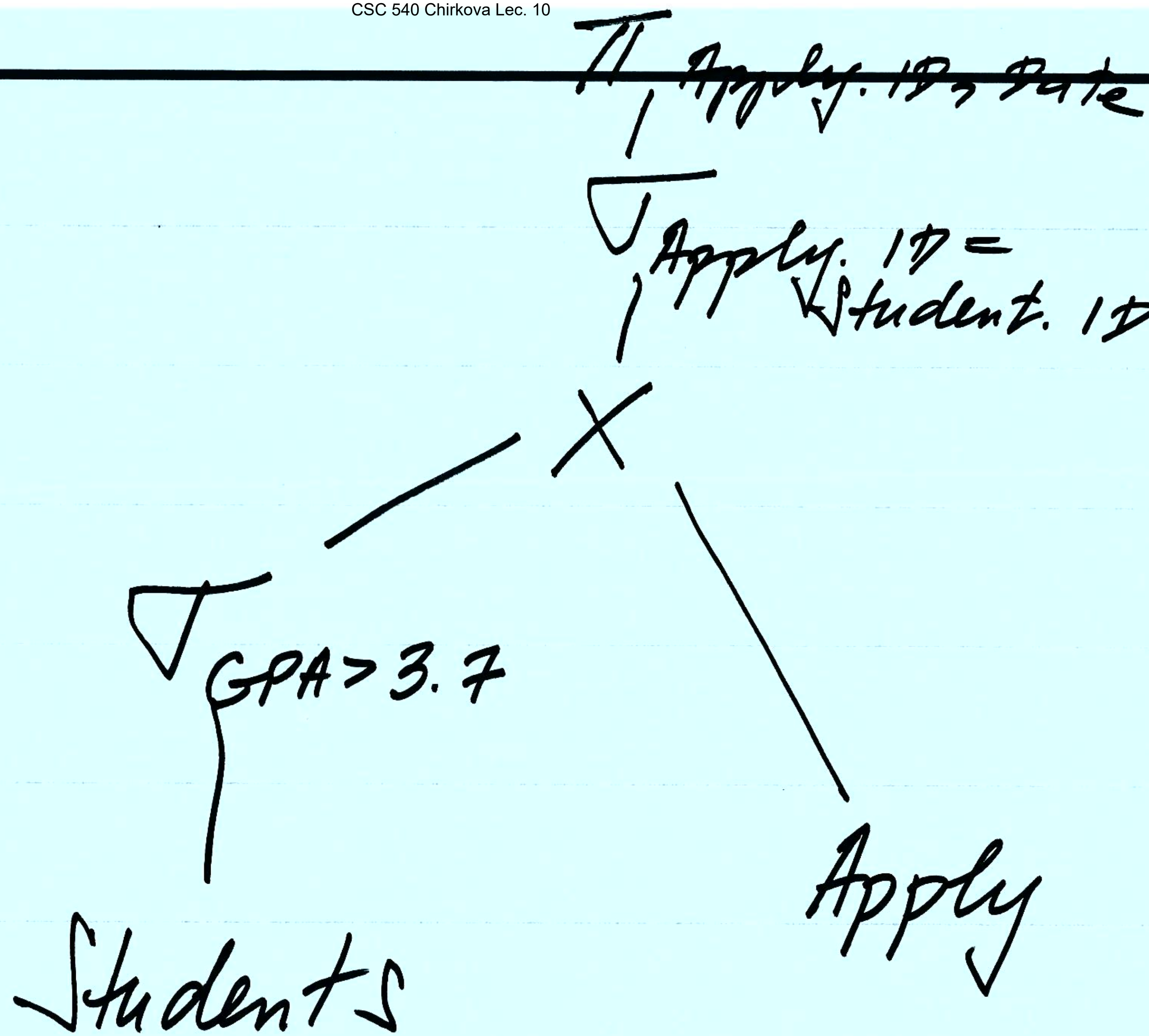
$$\pi_{Apply.ID,\ Date}\left(\sigma_{Apply.ID = Student.ID\ AND\ GPA \geq 3.7}\left(Apply \times Student\right)\right)$$

Q1:


$\pi_{Apply.ID,\ Date}$
$\sigma_{Apply.ID = Student.ID \text{ AND } GPA > 3.7}$
$\times$
Apply
Student

$$Q2: \pi_{Apply.ID,\ Date}\left(\sigma_{Apply.ID = Student.ID}\left(\sigma_{GPA > 3.7}(Students) \times Apply\right)\right)$$

Q2:



$R \bowtie_\theta S$ – theta join

$(R \bowtie_C S)$

$\uparrow$ Boolean condition

$$R \bowtie_C S \overset{\Delta}{\equiv} \sigma_C(R \times S)$$

$\uparrow$ defn

$$R \bowtie_{A > S.B \text{ OR } C = 10} S$$

(see answer on page for $R \times S$, the θ-column)

$$R \bowtie_{R.B = S.B} S$$

A	R.B	S.B	C	D
1	2	2	5	6
3	4	4	7	8

$$R \bowtie S \stackrel{\Delta}{\equiv} \pi_{\text{drop duplicates of same-name attributes}} \left(\sigma_{\text{equality on all same-name attributes}} (R \times S) \right)$$

$\Uparrow$ defn

U:

A	B	C
1	2	3
6	7	8
9	7	8

V:

B	C	D
2	3	4
2	3	5
7	8	10

$U \bowtie V$:

A	B	C	D
1	2	3	4
1	2	3	5
6	7	8	10
9	7	8	10

$U \bowtie_{A<D} V$:

A	U.B	U.C	V.B	V.C	D
1	2	3	2	3	4
1	2	3	2	3	5
1	2	3	7	8	10
6	7	8	7	8	10
9	7	8	7	8	10

$\pi_{\text{subset of attr}}$ (very large relation)

↓

expensive to eliminate duplicates

Relational algebra on bags:

$\{1, 1, 1\}$ – not a set

$\{\{1, 1, 1\}\}$ – multiset, or bag

$\{\{1, 2, 2, 2, 3, 3, 4, 4, 4\}\} =$

$= \{\{4, 3, 2, 1, 2, 3, 4, 2, 4\}\}$

Bag of tuples: (1) - tuple

(1, 2, 3) - tuple

{{(1), (1), (1), (2)}} - bag of tuples

{{(3, 4), (3, 4), (2, 1)}} - bag of tuples

contents of R(A, B):

R:

A	B
3	4
3	4
2	1

Relational algebra on bags:

Renaming: same as for sets

Selection: same as for sets

Projection: no duplicate removal – "bag projection"

Product (×): same as for sets

θ-join: same as for sets

(π different) * Natural Join: not same as for sets

Set operators: different – duplicates can arise in answers

R:

A	B
1	2
3	4
1	2

S:

B	C	D
1	2	3
2	1	4
3	4	8
2	1	4
2	3	8

R X S:

A	R.B	S.B	C	D
1	2	2	1	4
1	2	2	1	4
1	2	2	1	4
1	2	2	1	4
1	2	2	3	8
1	2	2	3	8

. . . . . .

(total 15 tuples)

$R \uplus S$ – "bag union"

(bag version of set union)

R: A B

S: A B