CSCC43 Assignment

Summer 2022

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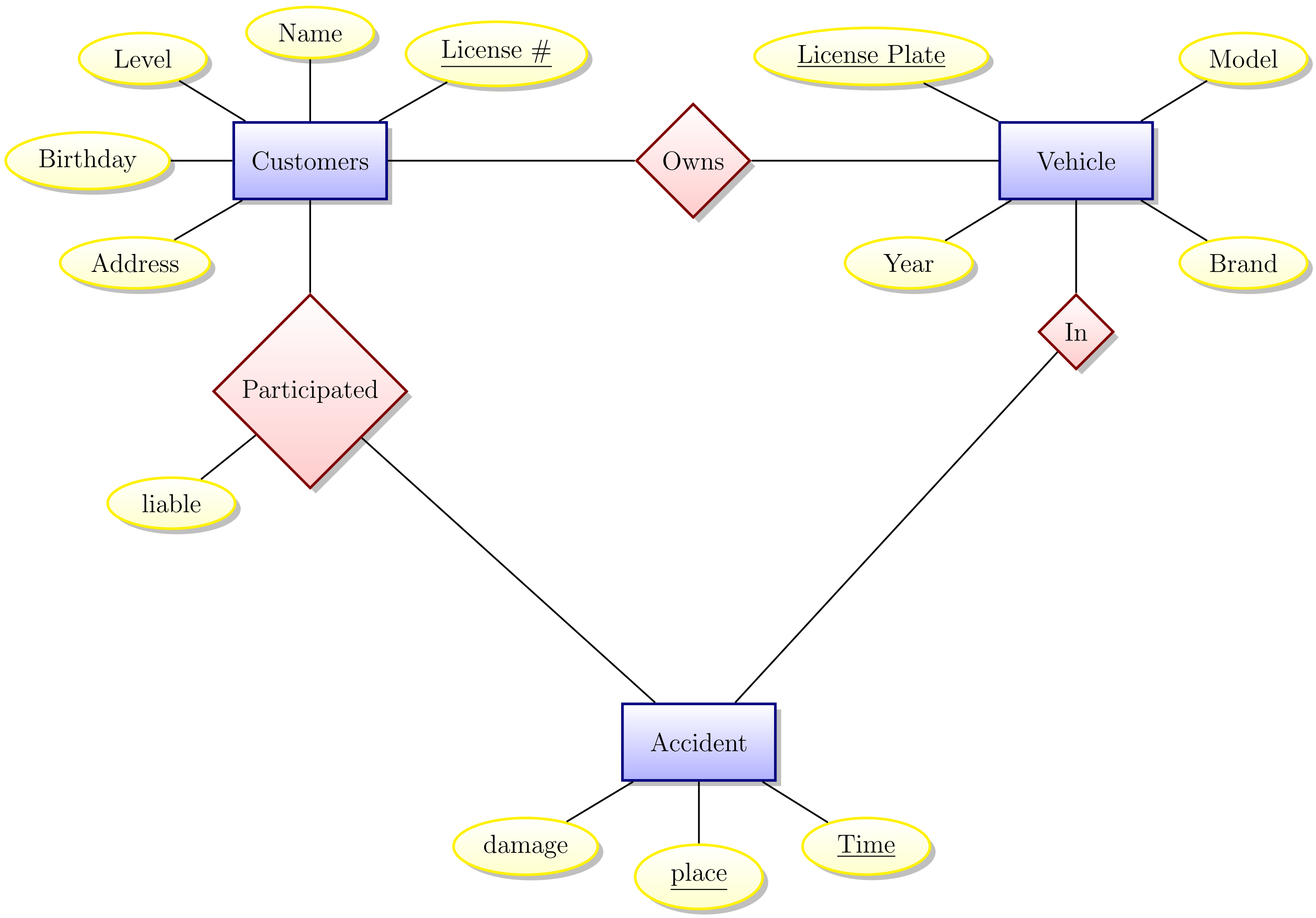
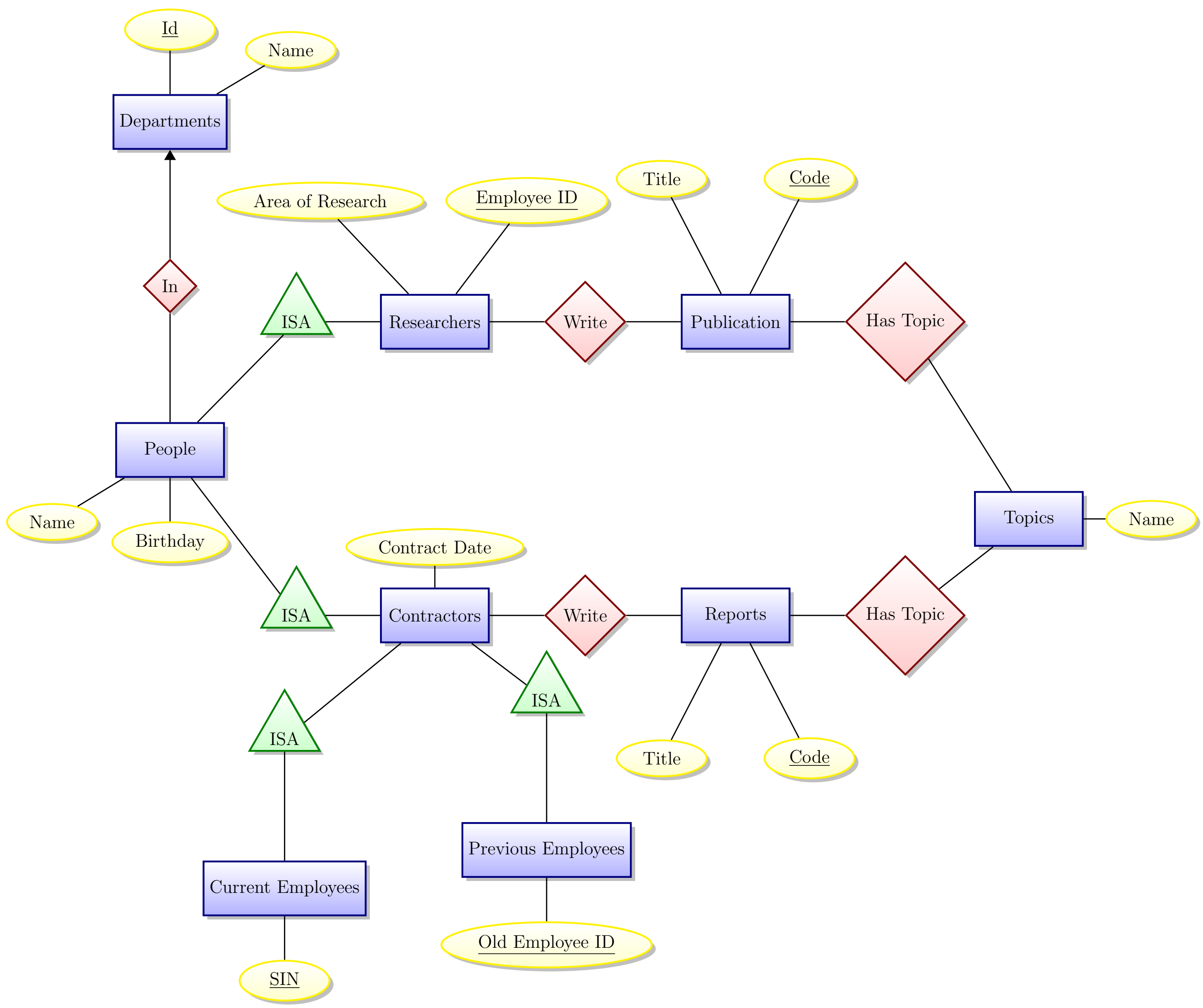
Exercise 1.



Everything is many to many

Exercise 2.



I assume that people can only belong to one Department.
I assume that Researchers are separate from Contractors, and that only Researchers get Employee ID since Current Employees only require a SIN.
I assume people can write many reports/publications and reports/publications can be written by multiple people.
Lastly, people can only be a Current Contractor, Previous Employee, or a Researcher. They cannot be in any parent entity set.

Department and Researchers					
Department		People		Researcher	
ID	Name	Name	Birthday	Area of Research	Employee ID
4819753	Psychology	Mashiro Tsukino	August 19 1996	Dreams	10035283874
1935517	Computer Science	Mei Hiuchidani	April 10 2000	Computational Complexity	10048173772

Department and Current Contractor					
Department		People		Contractor	Current Contractor
ID	Name	Name	Birthday	Contract Date	SIN
8457199	Math	Misaki Tobisawa	April 16 2003	May 2022 - December 2022	9271628316
1935517	Law	Limbo Scott Fitzgerald	April 10 1991	December 2021 - September 2022	9346336378

Department and Previous Employee					
Department		People		Contractor	Previous Employee
ID	Name	Name	Birthday	Contract Date	Old Employee ID
8457199	Sailor	Odette Malencon	November 3 1979	January 2015 - December 2017	10090218575
1935517	Police	Shu Lyn O'Keefe	June 26 1987	January 2022 - May 2022	10052155526

Researcher and Publication					
People		Researcher		Publication	
Name	Birthday	Area of Research	Employee ID	Title	Code
Kyou Tsukishima	August 20 2003	Basketball	10052155526	What's the best shooting form?	9892
Maya Tokizaki	April 26 2003	Acting	10038172316	Effects of exercise on acting	9887

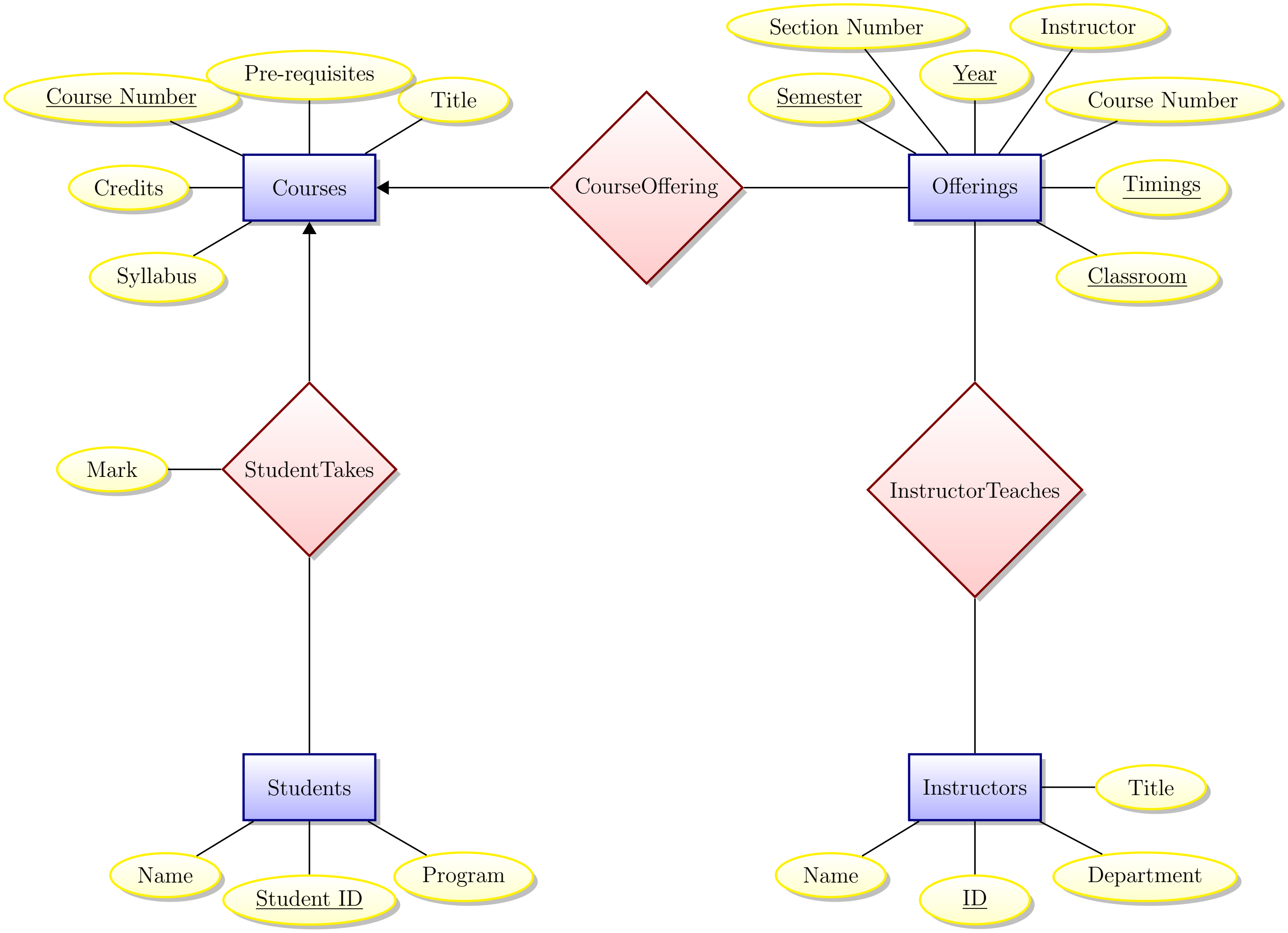
Current Contractors and Reports					
People		Contractor	Current Employee	Report	
Name	Birthday	Contract Date	SIN	Title	Code
Rikka Narusawa	June 29 2003	May 2022 - Dec 2022	9474987529	Correlation between hand size and piano skills	9799

Previous Employees and Reports					
People		Contractor	Previous Employee	Report	
Name	Birthday	Contract Date	Old Employee ID	Title	Code
Marika Shinozaki	Mar 3 2003	Dec 2021 - May 2022	10071291083	Effects of sexual intercourse during pregnency	9801

Publication and Topic		
Publication		Topic
Title	Code	Topic
Effects of sexual intercourse during pregnency	9801	Sex
Correlation between hand size and piano skills	9799	Music

Reports and Topic		
Reports		Topic
Title	Code	Topic
What's the best shooting form?	9892	Physics
Effects of exercise on acting	9887	Gym

Exercise 3.



I assume multiple instructors can teach a course

I assume the exact time and place of an offering is unique

Student Takes								
Courses					Students			Mark
Title	Pre-requisites	Course Number	Credits	Syllabus	Name	Student ID	Program	Mark
Compilers	CSCB58	CSCD70	0.5	PDF Link	Shiki Natsume	1004811742	CS	86
Imagination	PSYC16	STAB22	0.5	PDF Link	Kengo Miyazawa	1004848631	Psychology	61

Course Offerings										
Courses					Offerings					
Course #	Title	Pre-requisites	Credits	Syllabus	Semester	Year	Timings	Classroom	Section #	Instructor
MATD01	Rings	MATC01	0.5	Link	Fall	2022	9:00 - 11:00	HL B101	001	Alice Bedford
MDSB09	Kids	MDSA01	0.5	Link	Summer	2021	18:00 - 21:00	IC 130	002	Taichi Hoshina

Instructor Teaches									
Offerings						Instructors			
Semester	Year	Timings	Classroom	Section Number	Course Number	ID	Name	Title	Department
Summer	2016	11:00 - 13:00	SW 319	004	PHYC54	9993713655	Rino Ibaraki	Dr	Physics
Summer	2021	3:00 - 4:00	IC 212	001	VPSC04	9990840738	Ryuunosuke Arihara	Dr	Studio Art

Exercise 4.

(1)

$$\begin{aligned} & A \to C && \text{[By given]} \\ \iff & AB \to BC && \text{[By Augmentation]} \quad (\bigstar) \end{aligned}$$

$$\begin{aligned} & A \to B && \text{[By given]} \\ \iff & AA \to AB && \text{[By Augmentation]} \\ \iff & A \to AB && \text{[Simplifying]} \\ \iff & A \to BC && \text{[By Transivity from } (\bigstar)\text{]} \end{aligned}$$

(2)

$$\begin{aligned} & B \subseteq BC && \text{[Trivial]} \\ \iff & BC \to B && \text{[By Reflexivity]} \quad (\heartsuit) \end{aligned}$$

$$\begin{aligned} & C \subseteq BC && \text{[Trivial]} \\ \iff & BC \to C && \text{[By Reflexivity]} \quad (✿) \end{aligned}$$

$$\begin{aligned} & A \to BC && \text{[By given]} \\ \iff & A \to C && \text{[By Transivity from } (\heartsuit)\text{]} \\ \text{and} \quad & A \to B && \text{[By Transivity from } (✿)\text{]} \end{aligned}$$

(3)

$$\begin{aligned} & A \to B && \text{[By given]} \\ \iff & AC \to BC && \text{[Augmentation]} \\ \iff & AC \to D && \text{[By Transivity from given } BC \to D\text{]} \end{aligned}$$

(4)

$$\begin{aligned}
& C \to F && \text{[By given]} \\
\iff\ & CG \to FG && \text{[Augmentation with } G\text{]} && (\blacklozenge)
\end{aligned}$$

$$\begin{aligned}
& AB \to CD && \text{[By given]} \\
\iff\ & ABE \to CDE && [\text{Augmentation with } E] \\
\iff\ & ABE \to CDG && [E \to G \implies CDE \to CDG] \\
\iff\ & ABE \to CG && [CG \subseteq CGD \implies CGD \to CG] && (\text{🍃})
\end{aligned}$$

$$\begin{aligned}
& A \to B && \text{[By given]} \\
\iff\ & A \to DE && [B \to DE] \\
\iff\ & A \to E && [E \subseteq DE \implies DE \to E]
\end{aligned}$$

$$\begin{aligned}
& A \to BE && [\text{Union of } A \to B \text{ and } A \to E] \\
\iff\ & AA \to ABE && [\text{Augmentation with } A] \\
\iff\ & A \to ABE && \text{[Simplification]} \\
\iff\ & A \to CG && [\text{Transivity with (🍃)}] \\
\iff\ & A \to FG && [\text{Transivity with } (\blacklozenge)]
\end{aligned}$$

Exercise 5.

(1)

1. $A \to C$, $A \to D$
2. The only key is A since $A \to$ every other attribute. By the union property, $A \to ABCD$
3. All possible sets with A in it. So:

$$\begin{aligned}
AB &\to ABCD \\
AC &\to ABCD \\
AD &\to ABCD \\
ABC &\to ABCD \\
ABD &\to ABCD \\
ACD &\to ABCD \\
ABCD &\to ABCD
\end{aligned}$$

(2)

1.

$$\begin{aligned}
& BC \to D && \text{[given]} \\
\iff\ & ABC \to AD && \text{[Augmentation with } A\text{]} \\
\iff\ & ABC \to D && \text{[by decomposition rule]} \qquad (✈)
\end{aligned}$$

$$\begin{aligned}
& AB \to C && \text{[given]} \\
\iff\ & AABB \to ABC && \text{[Augmentation with } A \text{ and } B\text{]} \\
\iff\ & AB \to ABC && \text{[Simplifying]} \\
\iff\ & AB \to D && \text{[Augmentation with (✈)]}
\end{aligned}$$

$$
\begin{aligned}
& CD \to A && \text{[given]} \\
\iff\ & BCD \to BA && \text{[augmentation with } B\text{]} \\
\iff\ & BCD \to A && \text{[by decomposition rule]} && (\text{☕})
\end{aligned}
$$

$$
\begin{aligned}
& BC \to D && \text{[given]} \\
\iff\ & BBCC \to BCD && \text{[augmentation with } B \text{ and } C\text{]} \\
\iff\ & BC \to BCD && \text{[Simplifying]} \\
\iff\ & BC \to A && \text{[augmentation with (☕)]}
\end{aligned}
$$

$$
\begin{aligned}
& DA \to B && \text{[given]} \\
\iff\ & CDA \to CB && \text{[augmentation with } C\text{]} \\
\iff\ & CDA \to B && \text{[by decomposition rule]} && (\text{♫})
\end{aligned}
$$

$$
\begin{aligned}
& CD \to A && \text{[given]} \\
\iff\ & CCDD \to CDA && \text{[augmentation with } C \text{ and } D\text{]} \\
\iff\ & CD \to CDA && \text{[Simplifying]} \\
\iff\ & CD \to B && \text{[augmentation with (♫)]}
\end{aligned}
$$

$$
\begin{aligned}
& AB \to C && \text{[given]} \\
\iff\ & DAB \to DC && \text{[augmentation with } D\text{]} \\
\iff\ & DAB \to C && \text{[by decomposition rule]} && (\text{⭐})
\end{aligned}
$$

$$\begin{aligned} & DA \to B && \text{[given]} \\ \iff & DDAA \to DAB && \text{[augmentation with } D \text{ and } A\text{]} \\ \iff & DA \to DAB && \text{[Simplifying]} \\ \iff & DA \to C && \text{[augmentation with (}\star\text{)]} \end{aligned}$$

So there is:

$AB \to D$

$BC \to A$

$CD \to B$

$DA \to C$

2. By union property of the given and above, we have:

$AB \to ABCD$

$BC \to ABCD$

$CD \to ABCD$

$DA \to ABCD$

3. All possible sets with AB, BC, CD, and DA in it. So:

$ABC \to ABCD$

$BCD \to ABCD$

$CDA \to ABCD$

$DAB \to ABCD$

$ABD \to ABCD$

$BCA \to ABCD$

$CDB \to ABCD$

$DAC \to ABCD$

$ABCD \to ABCD$

Exercise 6.

(1)

$$\begin{aligned} A^+ &= (ABC)^+ && \text{[given } A \to BC\text{]} \\ &= (ABCD)^+ && \text{[given } B \to D\text{]} \\ &= ABCDE && \text{[given } CD \to E\text{]} \end{aligned}$$

$$\begin{aligned} E^+ &= (EA)^+ && \text{[given } E \to A\text{]} \\ &= ABCDE && \text{[since } A^+ = ABCDE\text{]} \end{aligned}$$

$$B^+ = BD \quad \text{[given } B \to D\text{]}$$

$$C^+ = C \quad \text{[nothing]}$$

$$D^+ = D \quad \text{[nothing]}$$

$$(BD)^+ = BD \quad \text{[nothing]}$$

$$\begin{aligned} (CD)^+ &= (CDE)^+ && \text{[given } CD \to E\text{]} \\ &= ABCDE && \text{[since } E^+ = ABCDE\text{]} \end{aligned}$$

$$\begin{aligned} (BC)^+ &= (BCD)^+ && \text{[given } B \to D\text{]} \\ &= ABCDE && \text{[since } (CD)^+ = ABCDE\text{]} \end{aligned}$$

So A, E, CD, and BC are candidate keys. since they functionally determines all other attributes. There exists no non-empty subset of A and E. And both subsets of BC (B and C) and CD (C and D) are not superkeys.

There cannot be a candidate key with 3 attributes because it must be a superset of one of $\{A, E, CD, BC\}$. All attributes exist in that set. Since those are candidate keys, then supersets of those attributes are by definition not candidate keys.

(2)
No. B is not a superkey of R since B is not a superset of $\{A, E, CD, BC\}$. Since $B \to D$ is a non-trivial Functional Dependency of R, R is not in BCNF.

(3)
Yes. The D in $B \to D$ is a member of CD which is a superkey. So $\{A, E, CD\}$ are superkeys, and D from the last Functional Dependency $B \to D$ is a member of the superkey CD

(4)
Initial Tableau:

Decomposed Relations	Attributes				
	A	B	C	D	E
$R_1(A, B, C)$	a	b	c	d_1	e_1
$R_2(A, D, E)$	a	b_2	c_2	d	e

Given $A \to BC$

Decomposed Relations	Attributes				
	A	B	C	D	E
$R_1(A, B, C)$	a	b	c	d_1	e_1
$R_2(A, D, E)$	a	$\boldsymbol{b}$	$\boldsymbol{c}$	d	e

Since we have a row without any subscripts, this means we have a lossless decomposition.
Checking dependency preserving: Let $F = \{A \to BC,\ CD \to E,\ B \to D,\ E \to A\}$ Check if $(F_{R_1} \cup F_{R_2})^+ = F^+$

$R_1 = (A, B, C),\ R_2 = (A, D, E)$
Given the Closures of everything in (1), we have:
$F_{R_1} = \{A \to BC,\ BC \to A\}$
$F_{R_2} = \{A \to DE,\ E \to AD\}$

$F_{R_1} \cup F_{R_2} = \{A \to BCDE,\ BC \to A,\ E \to A\}$

Calculating closure of $F_{R_1} \cup F_{R_2}$

$A^+ = ABCDE$
$B^+ = B \leftarrow$ This is not equal to F^+
$C^+ = C$
$D^+ = D$
$E^+ = ABCDE$
$BC^+ = ABCDE$
$CD^+ = CD \leftarrow$ This is not equal to F^+
$BD^+ = BD$

$\therefore \{CD \rightarrow E,\ B \rightarrow D\}$ are not preserved

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Initial Tableau:

Decomposed Relations	Attributes				
	A	B	C	D	E
$R_1(A, B, C, D)$	a	b	c	d	e_1
$R_2(C, D, E)$	a_2	b_2	c	d	e

Given $CD \rightarrow E$

Decomposed Relations	Attributes				
	A	B	C	D	E
$R_1(A, B, C, D)$	a	b	c	d	$\boldsymbol{e}$
$R_2(C, D, E)$	a_2	b_2	c	d	e

Since we have a row without any subscripts, this means we have a lossless decomposition.
Checking dependency preserving: Let $F = \{A \rightarrow BC,\ CD \rightarrow E,\ B \rightarrow D,\ E \rightarrow A\}$ Check if $(F_{R_1} \cup F_{R_2})^+ = F^+$

$R_1 = (A, B, C, D),\ R_2 = (C, D, E)$

Given the Closures of everything in (1), we have:
$F_{R_1} = \{A \rightarrow BCD,\ B \rightarrow D,\ BC \rightarrow A,\ CD \rightarrow A\}$
$F_{R_2} = \{E \rightarrow CD,\ CD \rightarrow E\}$

$F_{R_1} \cup F_{R_2} = \{A \rightarrow BCD,\ B \rightarrow D,\ BC \rightarrow A,\ CD \rightarrow A,\ E \rightarrow A\}$

Calculating closure of $F_{R_1} \cup F_{R_2}$

$A^+ = ABCDE$
$B^+ = BD$
$C^+ = C$
$D^+ = D$
$E^+ = ABCDE$
$BC^+ = ABCDE$
$CD^+ = ABCDE$
$BD^+ = BD$

$\because (F_{R_1} \cup F_{R_2})^+ = F^+$
$\therefore$ FD's are preserved

(5)
R_1's Functional Dependencies: $A \rightarrow BC$ which is a superkey
$\therefore R_1$ is in BCNF
$\implies R_1$ is in 3NF

R_2's Functional Dependencies: $E \rightarrow A$ which is neither a superkey or prime
$\therefore R_2$ is none

R_3's Functional Dependencies: $\{A \rightarrow BC,\ B \rightarrow D\}$
A is a superkey, so the first Functional Dependency is valid
The second Functional Dependency is neither a superkey or prime
$\therefore R_2$ is none

R_3's Functional Dependencies: $CD \rightarrow E$, which is a superkey
$\therefore R_4$ is in BCNF
$\therefore R_4$ is in 3NF

(6)
$A^+ = ABCDE$
$(CD)^+ = ABCDE$
$B^+ = BD$ [Violation of BCNF]
$E^+ = ABCDE$

$R_1 = BD$
$R_2 = ABCE$

Projecting FD's onto R_1
$B^+ = BD \implies B \to D$ which is a superkey
$D^+ = D$
$\therefore R_1$ sastifies BCNF

Projecting FD's onto R_2
$A^+ = ABCE \implies A \to BCE$ which is a superkey
$B^+ = B$
$C^+ = C$
$E^+ = ABCE \implies E \to ABC$ which is a superkey
$BC^+ = BC$
$\therefore R_2$ sastifies BCNF

So the relations $R_1 = BD$ and $R_2 = ABCE$ is in BCNF.

Checking dependency preserving: Let $F = \{A \to BC,\ CD \to E,\ B \to D,\ E \to A\}$ Check if $(F_{R_1} \cup F_{R_2})^+ = F^+$

$R_1 = (B, D),\ R_2 = (A, B, C, E)$

Given the Closures of everything in (1), we have:
$F_{R_1} = \{B \to D\}$
$F_{R_2} = \{A \to BCE,\ E \to A,\ BC \to A\}$

$F_{R_1} \cup F_{R_2} = \{A \to BCDE,\ B \to D,\ E \to A,\ CD \to A,\ BC \to A\}$

Calculating closure of $F_{R_1} \cup F_{R_2}$

$A^+ = ABCDE$
$B^+ = BD$
$C^+ = C$
$D^+ = D$
$E^+ = ABCDE$
$BC^+ = ABCDE$
$CD^+ = ABCDE$
$BD^+ = BD$

$\because (F_{R_1} \cup F_{R_2})^+ = F^+$
$\therefore$ FD's are preserved

Exercise 7.

Candidate keys:

$B^+ = (BO)^+$
$O^+ = O^+$
$I^+ = BOI$
$S^+ = SD$
$Q^+ = Q$
$D^+ = D$
$BO^+ = BO$
$BI^+ = BOI$
$BS^+ = BOSD$
$BQ^+ = BOQ$
$BD^+ = BOD$
$OI^+ = BOI$
$OS^+ = OSD$
$OQ^+ = OQ$
$OD^+ = OD$
$IS^+ = BOISQD$
$IQ^+ = BOIQ$
$ID^+ = BOID$
$SQ^+ = SQD$
$SD^+ = SD$
$QD^+ = QD$
$BOI^+ = BOI$
$BOS = BOSD$
$BOQ = BOQ$
$BOD = BOD$
$BIQ = BOIQ$
$BID = BOID$
$BSQ = BOSQD$
$BSD = BOSD$
$BQD = BOQD$
$OIQ = BOIQ$
$OID = BOID$
$OSQ = OSQD$
$OSD = OSD$
$OQD = OQD$
$IQD = BOIQD$
$SQD = SQD$
$BOIQ = BOIQ$
$BOID = BOID$
$BOSQ = BOSQD$
$BOSD = BOSD$
$BOQD = BOQD$
$BIQD = BOID$
$BSQD = BOSQD$
$OIQD = BOIQD$
$OSQD = OSQD$
$BOIQD = BOIQD$
$BOSQD = BOSQD$

So the only candidate key is IS.

BCNF:

$I^+ = BOI$

$I \to BO$ violates BCNF

$$\Downarrow$$

Let $R_1 = \{B,\ O,\ I\}$

Projecting FD's onto R_1

$B^+ = BO$

$B \to O$ Violates BCNF

Let $R_3 = \{B,\ O\}$

Let $R_4 = \{B,\ I\}$

Projecting FD's onto R_3

$B^+ = BO$ satisfies BCNF

$O^+ = O$

Projecting FD's onto R_4

$B^+ = B$

$I^+ = IB$ satisfies BCNF

Let $R_2 = \{I,\ S,\ Q,\ D\}$

Projecting FD's onto R_2

$I^+ = I$

$S^+ = SD$

$S \to D$ Violates BCNF

Let $R_5 = \{S,\ D\}$

Let $R_6 = \{I,\ S,\ Q\}$

Projecting FD's onto R_5

$S^+ = SD$ satisfies BCNF

$D^+ = D$

Projecting FD's onto R_6

$I^+ = I$

$S^+ = S$

$Q^+ = Q$

$(IS)^+ = ISQ$ satisfies BCNF

$(IQ)^+ = IQ$

$(SQ)^+ = SQ$

$\therefore R_3 = \{B,\ O\}$,

$R_4 = \{B,\ I\}$,

$R_5 = \{S,\ D\}$,

$R_6 = \{I,\ S,\ Q\}$ is in BCNF.

3NF:
$I^+ = BOI$
$I \to BO$ violates 3NF

$$\Downarrow$$

Let $R_1 = \{B,\ O,\ I\}$

Projecting FD's onto R_1
$B^+ = BO$
$B \to O$ Violates 3NF

Let $R_3 = \{B,\ O\}$
Let $R_4 = \{B,\ I\}$

Projecting FD's onto R_3
$B^+ = BO$ satisfies 3NF
$O^+ = O$

Projecting FD's onto R_4
$B^+ = B$
$I^+ = IB$ satisfies 3NF

Let $R_2 = \{I,\ S,\ Q,\ D\}$

Projecting FD's onto R_2
$I^+ = I$
$S^+ = SD$
$S \to D$ Violates 3NF

Let $R_5 = \{S,\ D\}$
Let $R_6 = \{I,\ S,\ Q\}$

Projecting FD's onto R_5
$S^+ = SD$ satisfies 3NF
$D^+ = D$

Projecting FD's onto R_6
$I^+ = I$
$S^+ = S$
$Q^+ = Q$
$(IS)^+ = ISQ$ satisfies 3NF
$(IQ)^+ = IQ$
$(SQ)^+ = SQ$

$\therefore R_3 = \{B,\ O\}$,
$R_4 = \{B,\ I\}$,
$R_5 = \{S,\ D\}$,
$R_6 = \{I,\ S,\ Q\}$ is in 3NF and BCNF.

Exercise 8.

1. $\pi_{\text{name}}\big(\sigma_{\text{sno=5}}(\text{students})\big)$

2. $\pi_{\text{universities.addr}}\Big(\sigma_{\text{study.uname=universities.uname, name=jones}}\big((\text{students} \bowtie \text{study}) \times \text{universities}\big)\Big)$

3. Students in Experiemnts = (students $\bowtie$ participate) $\bowtie$ experiment
   $\pi_{\text{uname, universities.addr}}\Big(\sigma_{\text{study.uname=universities.uname}}\big((\text{Students in Experiemnts} \bowtie \text{study})\times\text{universities}\big)\Big)$

4. Students in Experiemnts = (students $\bowtie$ participate) $\bowtie$ experiment
   Universities with students participating in Experiemnts =
   $\pi_{\text{uname, universities.addr}}\Big(\sigma_{\text{study.uname=universities.uname}}\big((\text{Students in Experiemnts} \bowtie \text{study})\times\text{universities}\big)\Big)$
   Universities $-$ Universities with students participating in Experiemnts

5. Students at Universities = $\sigma_{\text{study.uname=universities.uname}}\big((\text{students} \bowtie \text{study}) \times \text{universities}\big)$
   $\pi_{\text{eno, num-of-p, date}}\big((\text{Students at Universities} \bowtie \text{took-place}) \bowtie \text{experiment}\big)$

Exercise 9.

1. All floor department sales = (dept $\bowtie$ sales) $\bowtie$ item
   2^{nd} floor department sales = $\left(\left(\sigma_{\text{floor}=2}(\text{dept})\right) \bowtie \text{sales}\right) \bowtie \text{item}$
   $\pi_{\text{iname, type, color}}$(All floor department sales $-$ 2^{nd} floor department sales)

2. Assuming there is one manager per department.
   Managers = $\sigma_{\text{eno=mgr}}$(employee)
   Non-managers = employee $-$ Managers
   Max employee salary of each Department = $\gamma_{\text{dept, MAX(salary)}}$(Non-managers)
   $\sigma_{\text{salary>MAX(salary)}}$(Managers $\bowtie$ Max employee salary of each Department)

3. 2^{nd} floor department sales = $\left(\left(\sigma_{\text{floor}=2}(\text{dept})\right) \bowtie \text{sales}\right) \bowtie \text{item}$
   Items with number of departments = $\gamma_{\text{iname, COUNT(departments)}}$($2^{\text{nd}}$floor department sales)
   Items with more than two departments = $\sigma_{\text{COUNT(departments)}>2}$(Items with number of departments)
   $\pi_{\text{iname, type, color}}$(Items with more than two departments $\bowtie$ 2^{nd}floor department sales)

4. Supply equal to sales = $\left((\text{dept} \bowtie \text{sales}) \bowtie \text{item}\right) \bowtie \text{supply}$
   $\pi_{\text{iname, type, color}}$(Supply equal to sales)