Midterm 1 Solution Key

Question 1: Entity Relational Model

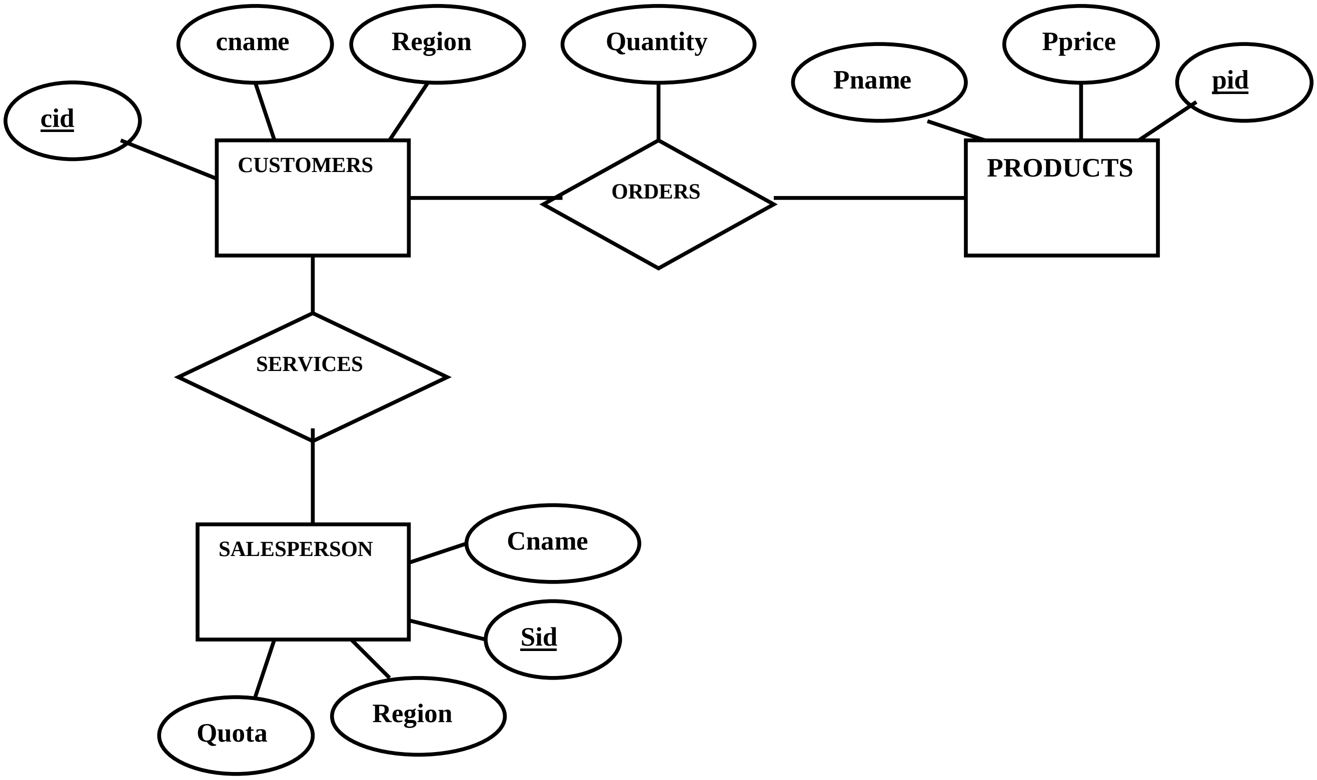
a. Answers needed to relate data independence to the SALESPERSON table, e.g. "if the data in the salesperson table is stored in a file system, and not in a relational DBMS, if we added a new field to the salesperson table the application would have to be aware of it. But a relational database gives us data independence by providing a separation between the way the data is stored on the file and the way the application accesses it".

b. Cardinality = 4; degree = 4

c. Name the primary keys: Salesperson: Sid (region is also acceptable); Products Pid; Customers Cid; Orders <cid, pid>. Quantity is NOT a primary key (point was taken off if you indicated it as a primary key)

d. Orders has a foreign key Cid references customers, Pid references products. If you indicated that the Region attribute of Customers is a foreign key, referencing the Region key of Salesperson, that is also OK.

e. The only connection between any of the Entities and Salespersons is the Region attribute, between Customers & Salespersons, so we are looking for a relationship ("services") between Customers & Salespersons. If you drew the Salesperson entity correctly, you got 4 points. One more point if you underlined sid. Then points were taken off for not having the right relationship, or not having it correctly drawn. Below is one possible solution.



Question 2

a. Maximum rotational delay:

1/7200 or 0.000139 sec
We also take 99/100 * 1/7200

(1 point was taken off if you indicated the average rotational delay or (½ * 1/7200))

Transfer rate:

512 * 100 * 7200 bytes/sec.

b. A slot directory is the on page data structure used to locate a variable length record on a page.
(A fix length record can also use a slot directory, if you explain how, you get credit.)
There is a <record offset, record length> pair per slot in the slot directory when used in a variable length record page. In a fix length record page, each slot has a flag indicating whether a particular slot is used or free.

Field offset refers to the offset from the beginning of a record, of a particular attribute (or field).
For instance, given the following schema: (sid: integer, name: char(30), grade: integer). The field offset of *name* should be 4 (since an int is 4 bytes.) Similarly the field offset of *grade* should be 34. (Note on some implementations, fields in records are required to be word aligned so, you may actually get 36 as the field offset for grade.)

c. LRU and MRU have the same performance, both result in 5 page I/Os for the given paging sequence. Some students forgot to count in the first 2 page accesses and put the number of I/Os for both algorithms as 3. But we also accepted that answer. If you only gave results to LRU or MRU, but did not show work, you may get only partial credit.

d. The problem is quite ambiguous. The ambiguity comes from two parts:
1. The job access pattern
2. The clock algorithm (i.e. whether or not advance the clock hand after reading a page already in the buffer pool) – however, there would not have been any ambiguity had you followed the pseudo code for clock from the class homepage.

We give full credit to anyone with a reasonable analysis. Something we are particularly looking for is like:

1. With a page access pattern like: 2, 1, 2, 2, 2, 3, 2, 4, 2, 5, 2. Then LRU would be best. (If you showed that the simulation of the clock algorithm performed equal to (even outperformed) LRU, and you showed your work you also received credit.)

2. If you said the job access pattern was like: 2, 1, 2, 3, 4, 5, 2, 1, 2, 3, 4, 5. Then MRU would be best.

Partial credit is given to any attempt that makes more or less sense.

Question 3

3.a1) Advantage of cluster index on sname: fast range search on sname field
1.5pts
a2) Disadvantage: Any other indices on Salesperson would have to be unclustered, so range search on those fields will be slow. Also there was overhead in maintaining the clustered property.
1.5pts
a3) Nonclustered: When there is already a cluster index on SID or if range search on SID is more common
2 pts

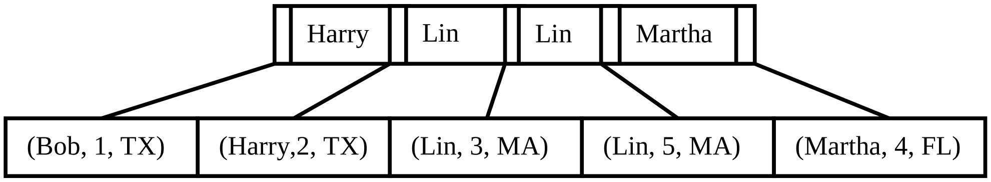
b) Number of I/Os : 1 header/directory page + 20 buckets = 21 in Alternative 1
1 header/directory page + 20 buckets + 20 data pages = 41 in Alternative 2

2 pts for correct answer
3 pts for an explanation

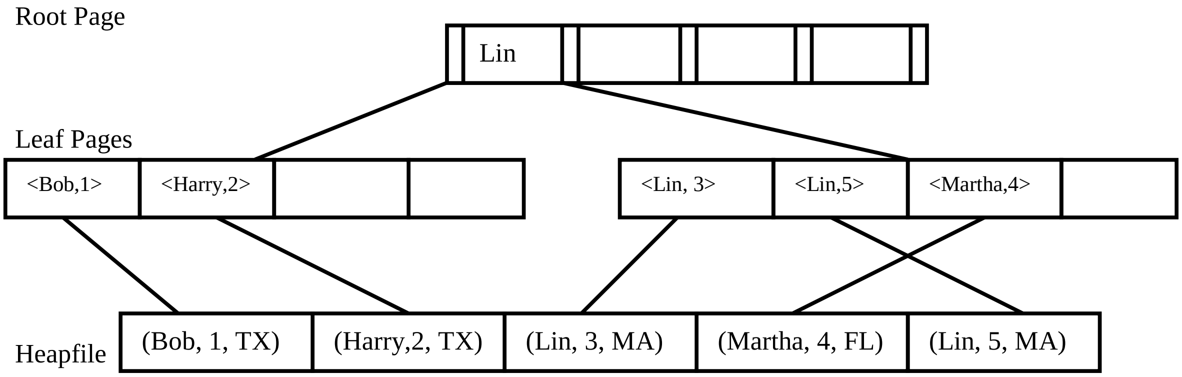
c) Using d = 2 and 1 data record per page, the tree has at least a root node and index nodes.

2 pts for correct index
2 pts for correct leaf
1 pt for overall correctness

Here is one possible Alternative 1 Solution:



In the above diagram, the leaves actually store the entire data record. So for the first leaf, you actually have (Bob, 1, TX) <cname, cid, region>
Here is one possible Alternative 2 Solution



In the leaf level (2nd level in the above diagram) the data entries are <Key, rid> (for simplicity, the rid is simply the page number of the page the actual data record is stored). The data records are stored in a heap file as depicted in the third level.

d) Advantage of Sparse index: index is smaller, easier to do range search.

2.5 pts

Disadvantage of Sparse: other indexes can't be clustered. Can't do optimization in the index because the index doesn't contain every record entry.

2.5 pts

Question 4. Relational Algebra:

A

1.

Cname	Cid	Region
Lin	3	MA
Lin	5	FL

1 point was taken off if you had only 1 row.

2.

Cname	Pid
Bob	152
Harry	152
Martha	831
Martha	131
Lin	255

3.

Cname
Mary

4.

Cname
Bob

5.

Name
Frances
Bob
Mary
Harry
Lin
Martha

1 point taken off if you had duplicates.

B

1. π cname σ region = “TX” (CUSTOMERS)

2. π cid (ORDERS $\bowtie$ orders.cid = products.cid (σ pname = ‘pcs’ PRODUCTS))

3. π sid ((((σ pname = ‘printers’ PRODUCTS $\bowtie$ products.pid = orders.pid ORDERS)
$\bowtie$ orders.cid = customers.cid CUSTOMERS)
$\bowtie$ customers.region = salesperson.region SALESPERSON)

Question 5. SQL

a) List the names of the customers who have bought more than one item.

```
SELECT cname
FROM customers
WHERE cid IN (SELECT cid
              FROM orders
              GROUP BY cid
              HAVING count(*) > 1)
```

Alternative: `HAVING sum(quantity) > 1)`

Other possible solutions

```
SELECT cname
FROM customers c, orders o1, orders o2
WHERE c.cid = o1.cid AND
      c.cid = o2.cid
      AND o1.pid <> o2.pid
```

```
SELECT c.cname
FROM customers c, (SELECT cid FROM orders
                              GROUP BY cid
                              HAVING count (*) > 1) as o
WHERE c.cid = o.cid
```

```
SELECT cname
FROM customers
WHERE 1 < (SELECT count(*)
           FROM orders o
           WHERE c.cid = o.cid)
```

e) List the names, pid, and price of all the products, whether or not the product has been ordered, but if it has been ordered display the cids of the customer who ordered it.

Solution 1:

```
SELECT name, pid, price, cid
FROM products LEFT OUTER JOIN orders
ON products.pid = orders.pid            <<<< optional
```

Solution 2:

```
SELECT name, p.pid, price, cid
FROM products p, orders o
WHERE p.pid = o.pid
UNION
SELECT name, pid, price, NULL as cid
FROM products p
WHERE cid NOT IN (SELECT cid FROM orders)
```

Alternatives:
```
WHERE NOT EXISTS (SELECT * FROM orders o WHERE o.pid = p.pid)
WHERE cid <> ANY (SELECT cid FROM orders)
```

f) List the names and cids of all customers, and, for those who have bought product, the total amount of money they owe for their purchases.

Solution 1:

```
SELECT c.name, c.cid, total = sum(price * quantity)
FROM customers c, orders o, products p
WHERE c.cid = o.cid AND o.pid = p.pid
GROUP BY c.name, c.cid
UNION
SELECT c.name, c.cid, totoal = NULL
FROM customers c
WHERE c.cid NOT IN (SELECT cid FROM orders)
```

Solution 2:

```
SELECT name, cid total = sum(price * quantity)
FROM costomer LEFT OUTER JOIN (orders INNER JOIN products)
```

```
GROUP BY cid
```

g) Find the sids of the salespeople for the regions where there are the most customers.

```
SELECT s.sid FROM salesperson
WHERE region IN (SELECT region
                 FROM customers
                 GROUP BY region
                 HAVING count(*) >= ALL (SELECT count(*)
                                         FROM customers
                                         GROUP BY region)
```

Alternative:
```
HAVING count(*) = (SELECT max(cnt)
                   FROM (SELECT count(*) as cnt
                         FROM customers
                         GROUP BY region)
```

h.

Sname
Frances
Bob
Mary

i.

Sid	Name
74	Lin

j.

Sid	Tsales
25	$1400
89	$1020

Points were taken off if you had 2 zero rows in your answer.

k.

Pname
Paper