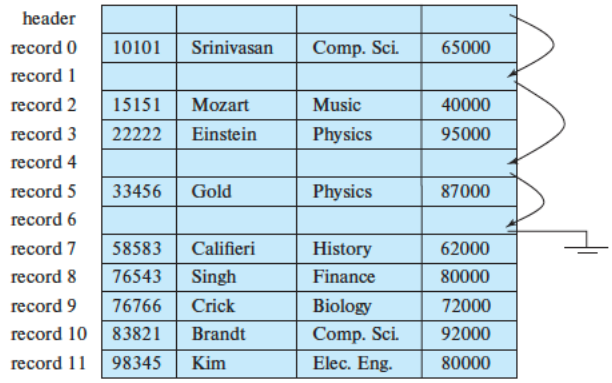
1. (30') Show the structure of the file of Figure below after each of the following steps:
   a. Insert (24556, Turnamian, Finance, 98000).
   b. Delete record 2.
   c. Insert (34556, Thompson, Music, 67000).



header				
record 0	10101	Srinivasan	Comp. Sci.	65000
record 1				
record 2	15151	Mozart	Music	40000
record 3	22222	Einstein	Physics	95000
record 4				
record 5	33456	Gold	Physics	87000
record 6				
record 7	58583	Califieri	History	62000
record 8	76543	Singh	Finance	80000
record 9	76766	Crick	Biology	72000
record 10	83821	Brandt	Comp. Sci.	92000
record 11	98345	Kim	Elec. Eng.	80000

Figure: File with free list after deletion of records 1, 4, 6.

2. (60') Consider a database with a single table T(song id,song name,artist id,duration number of streams), where song id is the primary key, and all attributes are the same fixed width. Suppose T has 10,000 tuples that fit into 500 pages, Ignore any additional storage overhead for the table (e.g., page headers, tuple headers). Additionally, you should make the following assumptions:

- The DBMS does not have any additional meta-data (e.g., sort order, zone maps).
- T does not have any indexes (including for primary key song id).
- None of T's pages are already in the buffer pool. The DMBS has an infinite buffer pool.
- Content-wise, the tuples of T will always make each query run the longest possible and do the most page accesses.
- The tuples of T can be in any order (keep this in mind when computing minimum versus maximum number of pages that the DBMS will potentially have to read and think of all possible orderings)
- There are 100 pages per attribute.

Part a.

```
SELECT MAX(number_of_streams) FROM T
    WHERE duration > 100 AND artist_id == 123321 ;
```

i. Suppose the DBMS uses the decomposition storage model (DSM) with implicit offsets. How many pages will the DBMS potentially have to read from disk to answer this query? (should be a range between the best case and the worst case, and why)

ii. Suppose the DBMS uses the N-ary storage model (NSM). How many pages will the DBMS potentially have to read from disk to answer this query? (should be a range between the best case and the worst case, and why)

Part b.

```
SELECT song_name, artist_id FROM T
    WHERE song_id = 15445 OR song_id = 15645 OR song_id = 15721;
```

i. Suppose the DBMS uses the decomposition storage model (DSM) with implicit offsets. What is the minimum and maximum number of pages that the DBMS will potentially have to read from disk to answer this query?

ii. Suppose the DBMS uses the N-ary storage model (NSM). What is the minimum and maximum number of pages that the DBMS will potentially have to read from disk to answer this query?

Part c.

```
SELECT song_id, number_of_streams FROM T
    WHERE duration = (SELECT MIN(duration) FROM T);
```

i. Suppose the DBMS uses the decomposition storage model (DSM) with implicit offsets. What is the minimum and maximum number of pages that the DBMS will potentially have to read from disk to answer this query?

ii. Suppose the DBMS uses the N-ary storage model (NSM). What is the minimum and maximum number of pages that the DBMS will potentially have to read from disk to answer this query?

3. (10') Consider the following relation Cars:

Brand	Type	Color	Risk
Opel	Corsa	Grey	Low
Opel	Corsa	Red	Medium
Peugeot	206	Black	Medium
BMW	A	Black	High

Construct a bitmap index for the attributes Brand and Color for this table.