Part 1:

```
CREATE TABLE Users (
    userID INT PRIMARY KEY,
    userEmail VARCHAR(255) UNIQUE NOT NULL,
    userPassword VARCHAR(255) NOT NULL,
    userBalance DECIMAL(12,2) DEFAULT 0.00,
    userSignedUpAt DATETIME NOT NULL
);

CREATE TABLE Grps (
    groupID INT PRIMARY KEY,
    groupName VARCHAR(255) NOT NULL,
    groupBalance DECIMAL(12,2) DEFAULT 0.00,
    groupCreatedAt DATETIME NOT NULL,
    groupCreatedBy INT NOT NULL,
    CONSTRAINT fk_group_creator
        FOREIGN KEY (groupCreatedBy) REFERENCES Users(userID)
);

CREATE TABLE GroupMemberships (
    userID INT NOT NULL,
    groupID INT NOT NULL,
    role VARCHAR(50),
    joinedAt DATETIME NOT NULL,
    PRIMARY KEY (userID, groupID),
    CONSTRAINT fk_gm_user
        FOREIGN KEY (userID) REFERENCES Users(userID),
    CONSTRAINT fk_gm_group
        FOREIGN KEY (groupID) REFERENCES Grps(groupID)
);

CREATE TABLE Tickers (
    symbol VARCHAR(10) PRIMARY KEY,
    name VARCHAR(255) NOT NULL,
    assetType VARCHAR(50) NOT NULL
);
```

```
CREATE TABLE PriceBars (
    ticker VARCHAR(10) NOT NULL,
    time DATETIME NOT NULL,
    open DECIMAL(12,2),
    high DECIMAL(12,2),
    low DECIMAL(12,2),
    close DECIMAL(12,2),
    volume BIGINT,
    source VARCHAR(20),
    PRIMARY KEY (ticker, time),
    CONSTRAINT fk_pb_ticker
        FOREIGN KEY (ticker) REFERENCES Tickers(symbol)
);

CREATE TABLE Transactions (
    transactionID INT PRIMARY KEY,
    accountID INT,
    groupID INT,
    ticker VARCHAR(10),
    time DATETIME NOT NULL,
    side VARCHAR(10),
    quantity DECIMAL(12,4),
    price DECIMAL(12,2),
    kind VARCHAR(20),
    status VARCHAR(20),
    requestedBy INT NOT NULL,
    approvedBy INT,
    CONSTRAINT fk_tx_group
        FOREIGN KEY (groupID) REFERENCES Grps(groupID),
    CONSTRAINT fk_tx_ticker
        FOREIGN KEY (ticker) REFERENCES Tickers(symbol),
    CONSTRAINT fk_tx_requestedBy
        FOREIGN KEY (requestedBy) REFERENCES Users(userID),
    CONSTRAINT fk_tx_approvedBy
        FOREIGN KEY (approvedBy) REFERENCES Users(userID)
);
```

Run Save Format Clear Valid

```sql
USE main;

SELECT
  g.groupID,
  g.groupName,
  COUNT(gm.userID)                AS members,
  ROUND(AVG(u.userBalance), 2)    AS avg_member_balance,
  ROUND(SUM(u.userBalance), 2)    AS total_member_balance
FROM Grps g
JOIN GroupMemberships gm ON gm.groupID = g.groupID
JOIN Users u             ON u.userID   = gm.userID
GROUP BY g.groupID, g.groupName
ORDER BY members DESC, total_member_balance DESC
LIMIT 15;

```

Results

Execution time: 31.7 ms Export

groupID	groupName	members	avg_member_balance	total_member_balance
1	Group 1	100	11262.50	1126250.00
2	Group 2	100	11262.50	1126250.00
3	Group 3	100	11262.50	1126250.00
4	Group 4	100	11262.50	1126250.00
5	Group 5	100	11262.50	1126250.00
6	Group 6	100	11262.50	1126250.00
7	Group 7	100	11262.50	1126250.00
8	Group 8	100	11262.50	1126250.00
9	Group 9	100	11262.50	1126250.00
10	Group 10	100	11262.50	1126250.00
11	Group 11	100	11262.50	1126250.00
12	Group 12	100	11262.50	1126250.00
13	Group 13	100	11262.50	1126250.00
14	Group 14	100	11262.50	1126250.00
15	Group 15	100	11262.50	1126250.00

Rows per page: 20 1 – 15 of 15

Run Save Format Clear Valid

```
1  USE main;
2
3  SELECT COUNT(*) AS row_count FROM GroupMemberships;
4
5  SELECT userID, groupID, role, joinedAt
6  FROM GroupMemberships
7  ORDER BY groupID, userID
8  LIMIT 15;
9
```

Results Execution time: 29.3 ms Export

All results > Result 1

row_count
4000

Rows per page: 20 1 – 1 of 1

Run Save Format Clear Valid

```
1  USE main;
2
3  SELECT COUNT(*) AS row_count FROM GroupMemberships;
4
5  SELECT userID, groupID, role, joinedAt
6  FROM GroupMemberships
7  ORDER BY groupID, userID
8  LIMIT 15;
9
```

Results Execution time: 29.3 ms Export

All results > Result 2

userID	groupID	role	joinedAt
1	1	owner	2025-10-31 22:18:00
2	1	trader	2025-10-31 22:18:00
3	1	trader	2025-10-31 22:18:00
4	1	trader	2025-10-31 22:18:00
5	1	trader	2025-10-31 22:18:00
6	1	trader	2025-10-31 22:18:00
7	1	trader	2025-10-31 22:18:00
8	1	trader	2025-10-31 22:18:00
9	1	trader	2025-10-31 22:18:00
10	1	trader	2025-10-31 22:18:00
11	1	trader	2025-10-31 22:18:00
12	1	trader	2025-10-31 22:18:00
13	1	trader	2025-10-31 22:18:00
14	1	trader	2025-10-31 22:18:00
15	1	trader	2025-10-31 22:18:00

Rows per page: 20 1 – 15 of 15

Run Save Format Clear Valid

```
1  USE main;
2
3  SELECT COUNT(*) AS row_count FROM Tickers;
4
5  SELECT symbol, name, assetType
6  FROM Tickers
7  ORDER BY symbol
8  LIMIT 15;
9
```

Results Execution time: 42.3 ms Export

All results > Result 2

symbol	name	assetType
A	Agilent Technologies, Inc. Common Stock	
AA	Alcoa Corporation Common Stock	
AACB	Artius II Acquisition Inc. - Class A Ordinary Shares	
AACBR	Artius II Acquisition Inc. - Rights	
AACBU	Artius II Acquisition Inc. - Units	
AACG	ATA Creativity Global - American Depositary Shares, each representing two common shares	
AACI	Armada Acquisition Corp. II - Class A Ordinary Shares	
AACIU	Armada Acquisition Corp. II - Units	
AACIW	Armada Acquisition Corp. II - Warrant	
AADR	AdvisorShares Dorsey Wright ADR ETF	
AAL	American Airlines Group, Inc. - Common Stock	
AALG	Leverage Shares 2X Long AAL Daily ETF	
AAM	AA Mission Acquisition Corp. Class A Ordinary Shares	
AAM.U	AA Mission Acquisition Corp. Units, each consisting of one Class A Ordinary Share and one	

Rows per page: 20 1 – 15 of 15

Run Save Format Clear Valid

```
USE main;

SELECT COUNT(*) AS row_count FROM Tickers;

SELECT symbol, name, assetType
FROM Tickers
ORDER BY symbol
LIMIT 15;
```

Results Execution time: 42.3 ms Export

All results > Result 1

row_count
8009

Rows per page: 20 1 – 1 of 1

Run Save Format Clear Valid

```
USE main;

SELECT COUNT(*) AS row_count FROM Users;

SELECT userID, userEmail, userBalance, userSignedUpAt
FROM Users
ORDER BY userID
LIMIT 15;

```

Results Execution time: 6.3 ms Export

All results > Result 2

userID	userEmail	userBalance	userSignedUpAt
0	userEmail	0.00	0000-00-00 00:00:00
1	user1@mail.com	10025.00	2025-10-31 22:15:35
2	user2@mail.com	10050.00	2025-10-31 22:15:35
3	user3@mail.com	10075.00	2025-10-31 22:15:35
4	user4@mail.com	10100.00	2025-10-31 22:15:35
5	user5@mail.com	10125.00	2025-10-31 22:15:35
6	user6@mail.com	10150.00	2025-10-31 22:15:35
7	user7@mail.com	10175.00	2025-10-31 22:15:35
8	user8@mail.com	10200.00	2025-10-31 22:15:35
9	user9@mail.com	10225.00	2025-10-31 22:15:35
10	user10@mail.com	10250.00	2025-10-31 22:15:35
11	user11@mail.com	10275.00	2025-10-31 22:15:35
12	user12@mail.com	10300.00	2025-10-31 22:15:35
13	user13@mail.com	10325.00	2025-10-31 22:15:35
14	user14@mail.com	10350.00	2025-10-31 22:15:35

Rows per page: 20 1 – 15 of 15

Run Save Format Clear Valid

```
USE main;

SELECT COUNT(*) AS row_count FROM Users;

SELECT userID, userEmail, userBalance, userSignedUpAt
FROM Users
ORDER BY userID
LIMIT 15;

```

Results Execution time: 6.3 ms Export

All results > Result 1

row_count
2101

Rows per page: 20 1 – 1 of 1

Part 2:

Query 1:

Variant A reduced plan cost from 4216 to 2216 by aligning the join and GROUP BY with groupID, enabling range scans over GroupMemberships. Variant B did not help because the leading column (userID) did not match the group-driven access pattern; the optimizer continued to choose the groupID path. Adding covering indexes on Users and Grps (Variant C) did not further reduce cost on our dataset. Users is small and remain cached, so index-only reads brought negligible savings. We select Variant A as the final design. Trade-off: slightly higher write cost and index storage, acceptable for our read-heavy analytics.

Baseline Results: Cost = 4216

```
1
2  SELECT
3    g.groupID,
4    g.groupName,
5    COUNT(gm.userID)                  AS members,
6    ROUND(AVG(u.userBalance), 2)      AS avg_member_balance,
7    ROUND(SUM(u.userBalance), 2)      AS total_member_balance
8  FROM Grps g
9  JOIN GroupMemberships gm ON gm.groupID = g.groupID
10 JOIN Users u           ON u.userID   = gm.userID
11 GROUP BY g.groupID, g.groupName
12 ORDER BY COUNT(gm.userID) DESC, SUM(u.userBalance) DESC
13 LIMIT 15;
```

Results — Execution time: 16.5 ms — Export

groupID	groupName	members	avg_member_balance	total_member_balance
1	Group 1	100	11262.50	1126250.00
2	Group 2	100	11262.50	1126250.00
3	Group 3	100	11262.50	1126250.00
4	Group 4	100	11262.50	1126250.00
5	Group 5	100	11262.50	1126250.00
6	Group 6	100	11262.50	1126250.00
7	Group 7	100	11262.50	1126250.00
8	Group 8	100	11262.50	1126250.00
9	Group 9	100	11262.50	1126250.00
10	Group 10	100	11262.50	1126250.00
11	Group 11	100	11262.50	1126250.00
12	Group 12	100	11262.50	1126250.00
13	Group 13	100	11262.50	1126250.00
14	Group 14	100	11262.50	1126250.00
15	Group 15	100	11262.50	1126250.00

Rows per page: 20 — 1 – 15 of 15

```
EXPLAIN ANALYZE
SELECT
  g.groupID,
  g.groupName,
  COUNT(gm.userID)             AS members,
  ROUND(AVG(u.userBalance),2)  AS avg_member_balance,
  ROUND(SUM(u.userBalance),2)  AS total_member_balance
FROM Grps g
JOIN GroupMemberships gm ON gm.groupID = g.groupID
JOIN Users u             ON u.userID   = gm.userID
GROUP BY g.groupID, g.groupName
ORDER BY COUNT(gm.userID) DESC, SUM(u.userBalance) DESC
LIMIT 15;
```

Results

Execution time: 22.9 ms Export

EXPLAIN

-> Limit: 15 row(s) (actual time=15.8..15.8 rows=15 loops=1) -> Sort: members DESC, `sum(u.userBalance)` DESC, limit input to 15 row(s) per chunk (actual time=15.8..15.8 rows=15 loops=1) -> Table scan on <temporary> (actual time=15.6..15.6 rows=40 loops=1) -> Aggregate using temporary table (actual time=15.6..15.6 rows=40 loops=1) -> Nested loop inner join (cost=4216 rows=4000) (actual time=0.194..7.26 rows=4000 loops=1) -> Nested loop inner join (cost=416 rows=4000) (actual time=0.178..1.84 rows=4000 loops=1) -> Table scan on g (cost=4.25 rows=40) (actual time=0.0863..0.112 rows=40 loops=1) -> Covering index lookup on gm using ix_gm_group (groupID=g.groupID) (cost=0.536 rows=100) (actual time=0.0224..0.0363 rows=100 loops=40) -> Single-row index lookup on u using PRIMARY (userID=gm.userID) (cost=0.85 rows=1) (actual time=0.00113..0.00116 rows=1 loops=4000)

Variant A Results: Stream results (cost=2216 rows=40)

Run Save Format Clear

Syntax error at or near "INDEX"

```
1  SHOW INDEX FROM GroupMemberships;
2
3  EXPLAIN ANALYZE
4  SELECT
5    g.groupID, g.groupName,
6    COUNT(gm.userID) AS members,
7    ROUND(AVG(u.userBalance),2) AS avg_member_balance,
8    ROUND(SUM(u.userBalance),2) AS total_member_balance
9  FROM Grps g
10 JOIN GroupMemberships gm ON gm.groupID = g.groupID
11 JOIN Users u             ON u.userID   = gm.userID
12 GROUP BY g.groupID, g.groupName
13 ORDER BY COUNT(gm.userID) DESC, SUM(u.userBalance) DESC
14 LIMIT 15;
15
16
```

Results

Execution time: 35.3 ms Export

All results > Result 2

EXPLAIN

-> Limit: 15 row(s) (actual time=23.2..23.2 rows=15 loops=1) -> Sort: members DESC, `sum(u.userBalance)` DESC, limit input to 15 row(s) per chunk (actual time=23.2..23.2 rows=15 loops=1) -> Stream results (cost=2216 rows=40) (actual time=2.63..23.1 rows=40 loops=1) -> Group aggregate: sum(u.userBalance), sum(u.userBalance), avg(u.userBalance), count(gm.userID) (cost=2216 rows=40) (actual time=2.62..23 rows=40 loops=1) -> Nested loop inner join (cost=1816 rows=4000) (actual time=0.0837..19 rows=4000 loops=1) -> Nested loop inner join (cost=416 rows=4000) (actual time=0.074..6.68 rows=4000 loops=1) -> Covering index scan on g using ix_grps_id_name (cost=4.25 rows=40) (actual time=0.0233..0.0818 rows=40 loops=1) -> Covering index lookup on gm using ix_gm_group (groupID=g.groupID) (cost=0.536 rows=100) (actual time=0.0916..0.154 rows=100 loops=40) -> Single-row index lookup on u using PRIMARY (userID=gm.userID) (cost=0.25 rows=1) (actual time=0.00274..0.00278 rows=1 loops=4000)

Variant B Results: Stream results (cost=2216 rows=40)

Run Save Format Clear

Syntax error at or near "ANALYZE"

```
1  DROP INDEX ix_gm_group_user ON GroupMemberships;
2  CREATE INDEX ix_gm_user_group ON GroupMemberships (userID, groupID);
3
4  EXPLAIN ANALYZE
5  SELECT
6    g.groupID, g.groupName,
7    COUNT(gm.userID) AS members,
8    ROUND(AVG(u.userBalance),2) AS avg_member_balance,
9    ROUND(SUM(u.userBalance),2) AS total_member_balance
10 FROM Grps g
11 JOIN GroupMemberships gm ON gm.groupID = g.groupID
12 JOIN Users u             ON u.userID   = gm.userID
13 GROUP BY g.groupID, g.groupName
14 ORDER BY COUNT(gm.userID) DESC, SUM(u.userBalance) DESC
15 LIMIT 15;
16
```

Results

Execution time: 203.9 ms Export

EXPLAIN

-> Limit: 15 row(s) (actual time=10.2..10.2 rows=15 loops=1) -> Sort: members DESC, `sum(u.userBalance)` DESC, limit input to 15 row(s) per chunk (actual time=10.2..10.2 rows=15 loops=1) -> Stream results (cost=2216 rows=40) (actual time=0.365..10.2 rows=40 loops=1) -> Group aggregate: sum(u.userBalance), sum(u.userBalance), avg(u.userBalance), count(gm.userID) (cost=2216 rows=40) (actual time=0.357..10.1 rows=40 loops=1) -> Nested loop inner join (cost=1816 rows=4000) (actual time=0.0721..7.33 rows=4000 loops=1) -> Nested loop inner join (cost=416 rows=4000) (actual time=0.0625..1.74 rows=4000 loops=1) -> Covering index scan on g using ix_grps_id_name (cost=4.25 rows=40) (actual time=0.0291..0.0554 rows=40 loops=1) -> Covering index lookup on gm using ix_gm_group (groupID=g.groupID) (cost=0.536 rows=100) (actual time=0.0212..0.0348 rows=100 loops=40) -> Single-row index lookup on u using PRIMARY (userID=gm.userID) (cost=0.25 rows=1) (actual time=0.00115..0.00118 rows=1 loops=4000)

Variant C Results: Stream results (cost=2216 rows=40)

Run Save Format Clear

Syntax error at or near "ANALYZE"

```
1  EXPLAIN ANALYZE
2  SELECT
3    g.groupID, g.groupName,
4    COUNT(gm.userID)            AS members,
5    ROUND(AVG(u.userBalance),2) AS avg_member_balance,
6    ROUND(SUM(u.userBalance),2) AS total_member_balance
7  FROM Grps g
8  JOIN GroupMemberships gm ON gm.groupID = g.groupID
9  JOIN Users u             ON u.userID   = gm.userID
10 GROUP BY g.groupID, g.groupName
11 ORDER BY COUNT(gm.userID) DESC, SUM(u.userBalance) DESC
12 LIMIT 15;
13
```

Results

Execution time: 49.5 ms Export

EXPLAIN

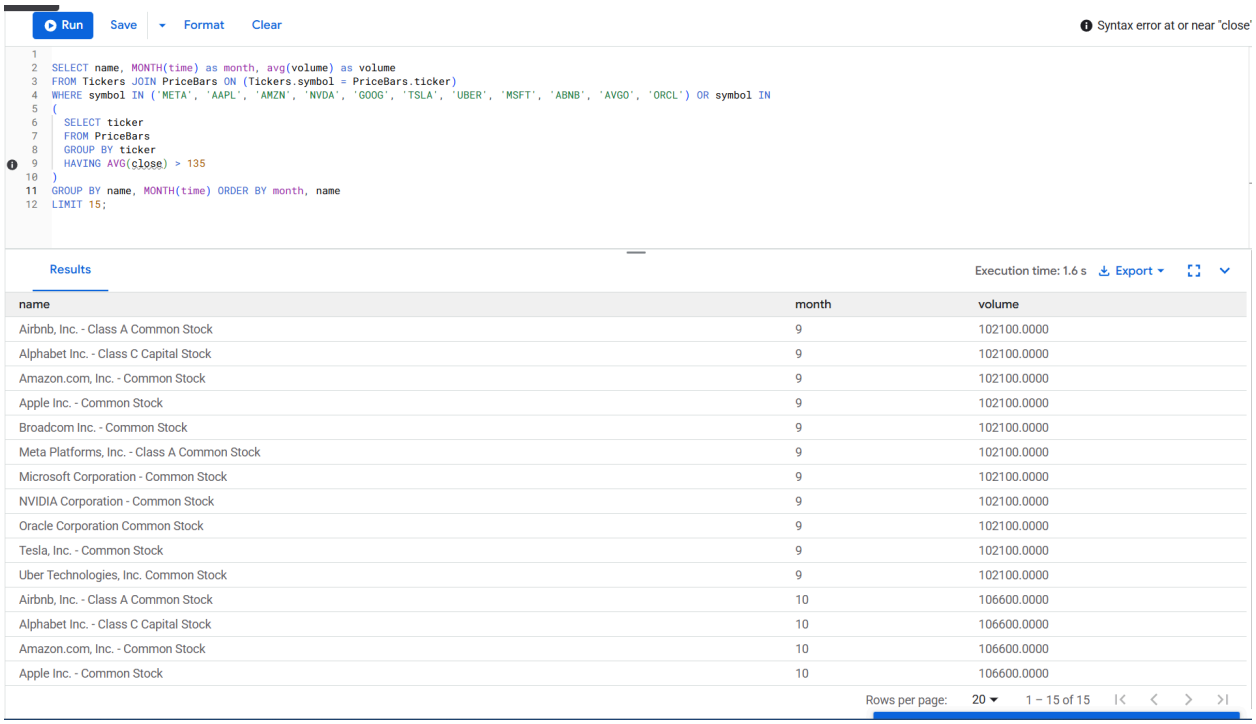
-> Limit: 15 row(s) (actual time=10.2..10.2 rows=15 loops=1) -> Sort: members DESC, `sum(u.userBalance)` DESC, limit input to 15 row(s) per chunk (actual time=10.2..10.2 rows=15 loops=1) -> Stream results (cost=2216 rows=40) (actual time=0.813..8.69 rows=40 loops=1) -> Group aggregate: sum(u.userBalance), sum(u.userBalance), avg(u.userBalance), count(gm.userID) (cost=2216 rows=40) (actual time=0.803..8.64 rows=40 loops=1) -> Nested loop inner join (cost=1816 rows=4000) (actual time=0.55..6.6 rows=4000 loops=1) -> Nested loop inner join (cost=416 rows=4000) (actual time=0.539..1.93 rows=4000 loops=1) -> Covering index scan on g using ix_grps_id_name (cost=4.25 rows=40) (actual time=0.0444..0.0611 rows=40 loops=1) -> Covering index lookup on gm using ix_gm_group (groupID=g.groupID) (cost=0.536 rows=100) (actual time=0.0175..0.0293 rows=100 loops=40) -> Single-row index lookup on u using PRIMARY (userID=gm.userID) (cost=0.25 rows=1) (actual time=963e-6..992e-6 rows=1 loops=4000)

Rows per page: 20 1 – 1 of 1

Query 2:

Based on the three variants, all decreased the total cost, although to varying degrees. When we did index on close and volume (A and B), both had a similar decrease to the cost, which makes sense as both are used in aggregation (close being in the having clause in subquery, and volume being returned in the outer query). Variant C had the largest impact, which is reasonable since it combined volume (which was related to the aggregation) and time which was related to grouping.

Baseline cost: 61204



name	month	volume
Airbnb, Inc. - Class A Common Stock	9	102100.0000
Alphabet Inc. - Class C Capital Stock	9	102100.0000
Amazon.com, Inc. - Common Stock	9	102100.0000
Apple Inc. - Common Stock	9	102100.0000
Broadcom Inc. - Common Stock	9	102100.0000
Meta Platforms, Inc. - Class A Common Stock	9	102100.0000
Microsoft Corporation - Common Stock	9	102100.0000
NVIDIA Corporation - Common Stock	9	102100.0000
Oracle Corporation Common Stock	9	102100.0000
Tesla, Inc. - Common Stock	9	102100.0000
Uber Technologies, Inc. Common Stock	9	102100.0000
Airbnb, Inc. - Class A Common Stock	10	106600.0000
Alphabet Inc. - Class C Capital Stock	10	106600.0000
Amazon.com, Inc. - Common Stock	10	106600.0000
Apple Inc. - Common Stock	10	106600.0000

```sql
EXPLAIN ANALYZE
SELECT name, MONTH(time) as month, avg(volume) as volume
FROM Tickers JOIN PriceBars ON (Tickers.symbol = PriceBars.ticker)
WHERE symbol IN ('META', 'AAPL', 'AMZN', 'NVDA', 'GOOG', 'TSLA', 'UBER', 'MSFT', 'ABNB', 'AVGO', 'ORCL') OR symbol IN
(
  SELECT ticker
  FROM PriceBars
  GROUP BY ticker
  HAVING AVG(close) > 135
)
GROUP BY name, MONTH(time) ORDER BY month, name;
```

Results — Execution time: 1.8 s — Export

EXPLAIN

-> Sort: `month`, Tickers.`name` (actual time=1773..1773 rows=22 loops=1) -> Table scan on <temporary> (actual time=1773..1773 rows=22 loops=1) -> Aggregate using temporary table (actual time=1773..1773 rows=22 loops=1) -> Nested loop inner join (cost=60943 rows=522621) (actual time=1700..1772 rows=660 loops=1) -> Filter: ((Tickers.symbol in ('META','AAPL','AMZN','NVDA','GOOG','TSLA','UBER','MSFT','ABNB','AVGO','ORCL')) or <in_optimizer>(Tickers.symbol,Tickers.symbol in (select #2))) (cost=1007 rows=8759) (actual time=1700..1771 rows=11 loops=1) -> Table scan on Tickers (cost=1007 rows=8759) (actual time=0.759..67.7 rows=8009 loops=1) -> Select #2 (subquery in condition; run only once) -> Filter: ((Tickers.symbol = `<materialized_subquery>`.ticker)) (cost=98820..98820 rows=1) (actual time=1699..1699 rows=0 loops=1) -> Limit: 1 row(s) (cost=98820..98820 rows=1) (actual time=1699..1699 rows=0 loops=1) -> Index lookup on <materialized_subquery> using <auto_distinct_key> (ticker=Tickers.symbol) (actual time=1699..1699 rows=0 loops=1) -> Materialize with deduplication (cost=98820..98820 rows=8010) (actual time=1699..1699 rows=0 loops=1) -> Filter: (avg(PriceBars.`close`) > 135) (cost=98019 rows=8010) (actual time=1699..1699 rows=0 loops=1) -> Group aggregate: avg(PriceBars.`close`) (cost=98019 rows=8010) (actual time=6.85..1696 rows=8009 loops=1) -> Index scan on PriceBars using PRIMARY (cost=50226 rows=477931) (actual time=6.81..1582 rows=480541 loops=1) -> Index lookup on PriceBars using PRIMARY (ticker=Tickers.symbol) (cost=0.877 rows=59.7) (actual time=0.102..0.121 rows=60 loops=11)

Rows per page: 20 — 1 – 1 of 1

Variant A:
Cost: 60982

Run — Save — Format — Clear — Syntax error at or near "ANALYZE"

```sql

#CREATE INDEX close ON PriceBars(close);

EXPLAIN ANALYZE
SELECT name, MONTH(time) as month, avg(volume) as volume
FROM Tickers JOIN PriceBars ON (Tickers.symbol = PriceBars.ticker)
WHERE symbol IN ('META', 'AAPL', 'AMZN', 'NVDA', 'GOOG', 'TSLA', 'UBER', 'MSFT', 'ABNB', 'AVGO', 'ORCL') OR symbol IN
(
  SELECT ticker
  FROM PriceBars
  GROUP BY ticker
  HAVING AVG(close) > 135
)
GROUP BY name, MONTH(time) ORDER BY month, name;
```

Results — Execution time: 1.2 s — Export

EXPLAIN

-> Sort: `month`, Tickers.`name` (actual time=1224..1224 rows=22 loops=1) -> Table scan on <temporary> (actual time=1224..1224 rows=22 loops=1) -> Aggregate using temporary table (actual time=1224..1224 rows=22 loops=1) -> Nested loop inner join (cost=60982 rows=522621) (actual time=1217..1223 rows=660 loops=1) -> Filter: ((Tickers.symbol in ('META','AAPL','AMZN','NVDA','GOOG','TSLA','UBER','MSFT','ABNB','AVGO','ORCL')) or <in_optimizer>(Tickers.symbol,Tickers.symbol in (select #2))) (cost=916 rows=8759) (actual time=1217..1223 rows=11 loops=1) -> Table scan on Tickers (cost=916 rows=8759) (actual time=1.83..4.47 rows=8009 loops=1) -> Select #2 (subquery in condition; run only once) -> Filter: ((Tickers.symbol = `<materialized_subquery>`.ticker)) (cost=98861..98861 rows=1) (actual time=1215..1215 rows=0 loops=1) -> Limit: 1 row(s) (cost=98861..98861 rows=1) (actual time=1215..1215 rows=0 loops=1) -> Index lookup on <materialized_subquery> using <auto_distinct_key> (ticker=Tickers.symbol) (actual time=1215..1215 rows=0 loops=1) -> Materialize with deduplication (cost=98861..98861 rows=8010) (actual time=1215..1215 rows=0 loops=1) -> Filter: (avg(PriceBars.`close`) > 135) (cost=98060 rows=8010) (actual time=1215..1215 rows=0 loops=1) -> Group aggregate: avg(PriceBars.`close`) (cost=98060 rows=8010) (actual time=3.21..1212 rows=8009 loops=1) -> Index scan on PriceBars using PRIMARY (cost=50267 rows=477931) (actual time=3.17..1104 rows=480541 loops=1) -> Index lookup on PriceBars using PRIMARY (ticker=Tickers.symbol) (cost=0.892 rows=59.7) (actual time=0.0268..0.0387 rows=60 loops=11)

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Variant B:
Cost: 60971

Variant C:
Cost: 60810

Query 3:

Results: The Baseline plan cost 63,100.87. Variant A (ticker,time) decreased cost to 62,301.61 by aligning with the join on ticker and the time filter, allowing range scans over the 180-day window before grouping. Variant B (time) only dropped to 62,965.90. This was optimized over time, but extra lookups by ticker limited gains. Variant C (covering: ticker,time,close,volume) matched baseline (63,100.87), meaning that index-only reads didn't trigger or didn't reduce work on this dataset. Choice: We select Variant A—it provides the best cost reduction with modest storage/write overhead.

Baseline cost: 63100.87

```
SELECT
  t.name,
  t.symbol,
  DATE_FORMAT(pb.time, '%Y-%m-01') AS month,
  AVG(pb.close)  AS avg_close,
  SUM(pb.volume) AS total_volume
FROM Tickers t
JOIN PriceBars pb ON pb.ticker = t.symbol
WHERE pb.time >= CURRENT_DATE - INTERVAL 180 DAY
GROUP BY t.name, t.symbol, month
ORDER BY month, t.name
LIMIT 15;
```

Results — Execution time: 7.7 s — Export

name	symbol	month	avg_close	total_volume
		2025-09-01	107.200000	2960900
	File Creat	2025-09-01	107.200000	2960900
1-800-FLOWERS.COM, Inc. - Class A Common Stock	FLWS	2025-09-01	107.200000	2960900
10x Genomics, Inc. - Common Stock	TXG	2025-09-01	107.200000	2960900
111, Inc. - American Depositary Shares	YI	2025-09-01	107.200000	2960900
17 Education & Technology Group Inc. - American Depositary Shares	YQ	2025-09-01	107.200000	2960900
1RT Acquisition Corp. - Class A Ordinary Share	ONCH	2025-09-01	107.200000	2960900
1RT Acquisition Corp. - Units	ONCHU	2025-09-01	107.200000	2960900
1RT Acquisition Corp. - Warrant	ONCHW	2025-09-01	107.200000	2960900
1st Source Corporation - Common Stock	SRCE	2025-09-01	107.200000	2960900
1stdibs.com, Inc. - Common Stock	DIBS	2025-09-01	107.200000	2960900

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Variant A: cost 62301.61

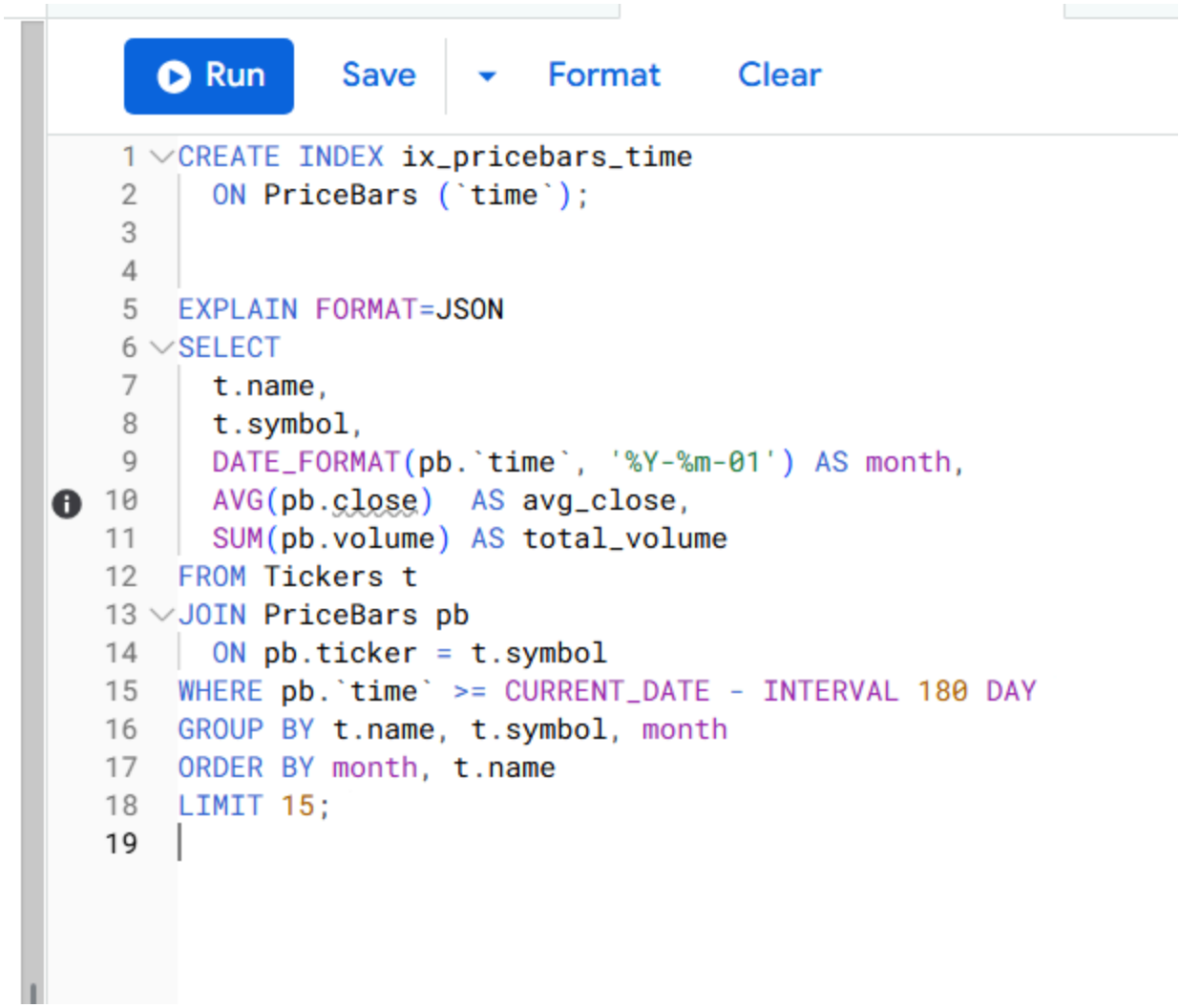
```sql
#CREATE INDEX ix_pricebars_ticker_time
  #ON PriceBars (ticker, `time`);



EXPLAIN FORMAT=JSON
SELECT
  t.name,
  t.symbol,
  DATE_FORMAT(pb.`time`, '%Y-%m-01') AS month,
  AVG(pb.close)  AS avg_close,
  SUM(pb.volume) AS total_volume
FROM Tickers t
JOIN PriceBars pb
  ON pb.ticker = t.symbol
WHERE pb.`time` >= CURRENT_DATE - INTERVAL 180 DAY
GROUP BY t.name, t.symbol, month
ORDER BY month, t.name
LIMIT 15;

```

Variant B: 62965.90



Variant C: 63100.87

Running... Save Format Clear

```
1  CREATE INDEX ix_pricebars_cover
2    ON PriceBars (ticker, `time`, close, volume);
3  EXPLAIN FORMAT=JSON
4  SELECT
5    t.name,
6    t.symbol,
7    DATE_FORMAT(pb.`time`, '%Y-%m-01') AS month,
8    AVG(pb.close)  AS avg_close,
9    SUM(pb.volume) AS total_volume
10 FROM Tickers t
11 JOIN PriceBars pb
12   ON pb.ticker = t.symbol
13 WHERE pb.`time` >= CURRENT_DATE - INTERVAL 180 DAY
14 GROUP BY t.name, t.symbol, month
15 ORDER BY month, t.name
16 LIMIT 15;
17
18
```

QUERY 4: The Baseline plan cost 498. Variant A decreased cost to 638 by creating an index on the filter column, allowing the optimizer to perform a range scan over the rows with userBalance above the average instead of a full table scan. Variant B maintained the same estimated cost of 638; although the descending index allowed the database to retrieve rows in order directly for the ORDER BY clause, it did not reduce the estimated cost compared to Variant A. Variant C increased the estimated cost to 742, as the additional columns widened the index but did not help with the subquery or the main filter, meaning index-only reads did not reduce work. We select Variant A as it provides the best balance of cost reduction and minimal storage/write overhead while aligning perfectly with the query filter.

Baseline: 498

```sql
SELECT
    u.userID,
    u.userEmail,
    u.userBalance
FROM Users u
WHERE u.userBalance >
    (SELECT AVG(userBalance) FROM Users)
ORDER BY u.userBalance DESC
LIMIT 15;
```

Results

userID	userEmail	userBalance
627	taylor.626@inbox.com	49973.01
1595	drew.1594@inbox.com	49961.90
380	devon.379@mail.com	49924.84
405	rowan.404@mail.com	49889.29
1047	alex.1046@inbox.com	49874.42
2010	casey.2009@email.com	49788.26
1669	skyler.1668@email.com	49746.27
721	reese.720@inbox.com	49736.77
1251	taylor.1250@example.com	49722.75
1126	kai.1125@inbox.com	49713.08
1596	taylor.1595@inbox.com	49700.21
396	drew.395@example.com	49686.82
1099	chris.1098@mail.com	49681.30
295	drew.294@example.com	49543.16
1258	chris.1257@inbox.com	49538.34

Rows per page:

```
EXPLAIN ANALYZE
SELECT u.userID, u.userEmail, u.userBalance
FROM Users u
WHERE u.userBalance > (
    SELECT AVG(userBalance) FROM Users
)
ORDER BY u.userBalance DESC
LIMIT 15;
```

Results — Execution time: 3.7 ms — Export

EXPLAIN

-> Limit: 15 row(s) (cost=74 rows=15) (actual time=2.38..2.38 rows=15 loops=1) -> Sort: u.userBalance DESC, limit input to 15 row(s) per chunk (cost=74 rows=2101) (actual time=2.37..2.38 rows=15 loops=1) -> Filter: (u.userBalance > (select #2)) (cost=74 rows=2101) (actual time=1.27..2.13 rows=1037 loops=1) -> Table scan on u (cost=74 rows=2101) (actual time=0.0743..0.682 rows=2101 loops=1) -> Select #2 (subquery in condition; run only once) -> Aggregate: avg(Users.userBalance) (cost=424 rows=1) (actual time=1.14..1.14 rows=1 loops=1) -> Table scan on Users (cost=214 rows=2101) (actual time=0.033..0.806 rows=2101 loops=1)

Variant A: 638

```
#CREATE INDEX idx_users_balance_A ON Users(userBalance);
EXPLAIN ANALYZE
SELECT u.userID, u.userEmail, u.userBalance
FROM Users u
WHERE u.userBalance > (
    SELECT AVG(userBalance) FROM Users
)
ORDER BY u.userBalance DESC
LIMIT 15;
```

Results — Execution time: 8.0 ms — Export

EXPLAIN

-> Limit: 15 row(s) (cost=214 rows=15) (actual time=1.46..1.46 rows=15 loops=1) -> Filter: (u.userBalance > (select #2)) (cost=214 rows=1037) (actual time=1.45..1.46 rows=15 loops=1) -> Index range scan on u using idx_users_balance_A over (24759.85 <= userBalance) (reverse) (cost=214 rows=1037) (actual time=1.45..1.45 rows=15 loops=1) -> Select #2 (subquery in condition; run only once) -> Aggregate: avg(Users.userBalance) (cost=424 rows=1) (actual time=1.11..1.11 rows=1 loops=1) -> Covering index scan on Users using idx_users_balance_A (cost=214 rows=2101) (actual time=0.189..0.718 rows=2101 loops=1)

Variant B: 638

```
#CREATE INDEX idx_users_balance_desc_B ON Users(userBalance DESC);
EXPLAIN ANALYZE
SELECT u.userID, u.userEmail, u.userBalance
FROM Users u
WHERE u.userBalance > (
    SELECT AVG(userBalance) FROM Users
)
ORDER BY u.userBalance DESC
LIMIT 15;
```

Results — Execution time: 13.6 ms — Export

EXPLAIN

-> Limit: 15 row(s) (cost=214 rows=15) (actual time=1.27..1.28 rows=15 loops=1) -> Filter: (u.userBalance > (select #2)) (cost=214 rows=1037) (actual time=1.27..1.27 rows=15 loops=1) -> Index range scan on u using idx_users_balance_desc_B over (userBalance <= 24759.85) (cost=214 rows=1037) (actual time=1.26..1.26 rows=15 loops=1) -> Select #2 (subquery in condition; run only once) -> Aggregate: avg(Users.userBalance) (cost=424 rows=1) (actual time=2.41..2.41 rows=1 loops=1) -> Covering index scan on Users using idx_users_balance_A (cost=214 rows=2101) (actual time=0.05..0.491 rows=2101 loops=1)

Variant C: 742

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Syntax error at or near "AI

```
#CREATE INDEX idx_users_covering_C ON Users(userBalance, userID, userEmail);
EXPLAIN ANALYZE
SELECT u.userID, u.userEmail, u.userBalance
FROM Users u
WHERE u.userBalance > (
    SELECT AVG(userBalance) FROM Users
)
ORDER BY u.userBalance DESC
LIMIT 15;
```

Results

Execution time: 14.3 ms | Export

EXPLAIN

-> Limit: 15 row(s) (cost=318 rows=15) (actual time=1.18..1.19 rows=15 loops=1) -> Filter: (u.userBalance > (select #2)) (cost=318 rows=1037) (actual time=1.18..1.19 rows=15 loops=1) -> Index range scan on u using idx_users_balance_desc_B over (userBalance <= 24759.85) (cost=318 rows=1037) (actual time=1.17..1.18 rows=15 loops=1) -> Select #2 (subquery in condition; run only once) -> Aggregate: avg(Users.userBalance) (cost=424 rows=1) (actual time=1.86..1.86 rows=1 loops=1) -> Covering index scan on Users using idx_users_balance_A (cost=214 rows=2101) (actual time=0.0544..0.5 rows=2101 loops=1)

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