Original Relations Before Normalisation
FINANCIAL_GOAL(Phone, Goal, Amount, Timeline)
RISK_TOLERANCE(Phone, Risk Level, Q1, Q2, Q3, Q4, Q5)
INVESTOR(Phone, Name, Gender, DoB, Annual Income, Company)
PORTFOLIO(Phone, PID, Annualised Return, Inception Date, Market Value, Fee)
INVESTED_VALUE(Phone, PID, Date, Amount)
UNREALISED_GAIN/LOSS(Phone, PID, Date, Amount)
STOCK_IN_PORTFOLIO(PID, ASSET-ID, STOCK-ID, Start Date, Allocation Ratio, Post-Trade CO)
TRANSACTION(PID, ID, Date, Type, Fee)
STOCK(ASSET-ID, P/E ratio, EPS, EBITDA)
BOND_IN_PORTFOLIO(PID, ASSET-ID, BOND-ID, Start Date, Allocation Ratio, Post-Trade CO)
BOND(ASSET-ID, Interest Rate, Maturity Date)
FUND_IN_PORTFOLIO(PID, ASSET-ID, FUND-ID, Start Date, Allocation Ratio, Post-Trade CO)
FUND(ASSET-ID, Expense Ratio, Dividend Yield)
ASSET(ASSET-ID, Name, Price)

Relations - Already in 3NF

FINANCIAL_GOAL
Let A, B, C, D denote the attributes Phone, Goal, Amount and Timeline respectively.

FINANCIAL_GOAL(A, B, C, D)
Keys: AB
Primary Key: AB
Functional Dependencies: AB -> CD

Inspecting AB -> CD shows that it does not violate 3NF, as AB is a key.

Hence FINANCIAL_GOAL(Phone, Goal, Amount, Timeline) is already in 3NF.

INVESTOR
Let A, B, C, D, E, F denote the attributes Phone, Name, Gender, DoB, Annual Income, Company.

INVESTOR(A, B, C, D, E, F)
Keys: A
Primary Key: A
Functional Dependencies: A -> BCDEF

Inspecting A -> BCDEF shows that it does not violate 3NF, as A is a key.

Hence INVESTOR(Phone, Name, Gender, DoB, Annual Income, Company) is already in 3NF.

PORTFOLIO
Let A, B, C, D, E, F denote the attributes Phone, PID, Annualised Return, Inception Date, Market Value and Fee.

Keys : AB
Primary key: AB
Functional Dependencies : AB -> CDEF

Inspecting AB -> CDEF shows that it does not violate 3NF, as AB is a key.

Hence PORTFOLIO(Phone, PID, Annualised Return, Inception Date, Market Value, Fee) is already in 3NF.

INVESTED_VALUE
Let A, B, C, D denote the attributes Phone, PID, Date and Amount.

Keys: ABC
Primary Keys: ABC
FDs : ABC -> D

Inspecting ABC -> D shows that it does not violate 3NF, as ABC is a key.

Hence INVESTED_VALUE(Phone, PID, Date, Amount) is already in 3NF.

UNREALIZED_GAIN/LOSS
Let A, B, C, D denote the attributes Phone, PID and Date and Amount

UNREALIZED GAIN/LOSS(A, B, C, D)

Keys: ABC
Primary Keys: ABC

FDs: ABC → D

Inspecting ABC -> D shows that it does not violate 3NF, as ABC is a key

Hence UNREALIZED GAIN/LOSS(A, B, C, D) is already in 3NF.

TRANSACTION
Let A, B, C, D, E denote the attribute PID, ID, Date, Type, Fee
TRANSACTION(A, B, C, D, E)

Keys: ABC
Primary Keys: ABC

FDs: ABC → DE

Inspecting ABC -> DE shows that it does not violate 3NF, as ABC is a key

Hence TRANSACTION(A, B, C, D) is already in 3NF.

STOCK
Let A, B, C, D denote the attributes ASSET-ID, P\E ratio, EPS and EBITDA.

STOCK(A, B, C, D)
Keys: A
Primary Key: A
Functional Dependencies: A -> BCD

Inspecting A -> BCD shows that it does not violate 3NF, as A is a key.

Hence STOCK(ASSET-ID, P/E ratio, EPS, EBITDA) is already in 3NF.

BOND
Let A, B, C denote the attributes ASSET-ID, Interest Rate, Maturity Date

BOND(A,B,C)
Keys: A
Primary Key: A
Functional Dependencies: A->BC

Inspecting A->BC shows that it does not violate 3NF, as A is a key.

Hence BOND(ASSET-ID, Interest Rate, Maturity Date) is already in 3NF.

FUND
Let A, B, C denote the attributes ASSET-ID, Expense Ratio, Dividend Yield respectively.
FUND(A,B,C)
Keys: A
Primary Key: A
Functional Dependencies:: A->BC
Inspecting A -> BC shows that it does not violate 3NF, as A is a key.

Hence FUND(ASSET-ID, Expense Ratio, Dividend Yield) is already in 3NF.

ASSET
Let A, B, C denote the attributes ASSET-ID, Name, Price respectively.
ASSET(A,B,C)
Keys: A
Primary Key: A
Functional Dependencies:: A->BC
Inspecting A -> BC shows that it does not violate 3NF, as A is a key.

Hence ASSET(ASSET-ID, Name, Price) is already in 3NF.

Relations - Not in 3NF

RISK_TOLERANCE
Let A, B, C, D, E, F, G denote the attributes Phone, Risk Level, Q1, Q2, Q3, Q4 and Q5 respectively.

RISK_TOLERANCE(A, B, C, D, E, F, G)
Keys: AB
Primary Key: AB
Functional Dependencies: A -> B, A -> CDEFG, CDEFG -> B

Inspecting A -> CDEFG shows that it violates 3NF, as A is not a superkey and CDEFG is not contained in a key.
Hence, we find the minimal basis. Decomposing the FDs to only have a single RHS attribute we get:

{A -> B, A -> C, A -> D, A -> E, A -> F, A -> G, CDEFG -> B}

From above, we can see that A->B is redundant, as A -> CDEFG, CDEFG -> B (Transitivity Rule).

Next, we inspect if there are any redundant attributes on the LHS of any FD. Upon inspection, there is none – no further amendments needed.

Hence, minimal basis = {A -> C, A -> D, A -> E, A -> F, A -> G, CDEFG -> B}

Combining the FDs whose LHS are the same we get:

{A -> CDEFG, CDEFG -> B}

Decomposition into two tables containing the attributes of each FD gives us:

R1(A, C, D, E, F, G)
R2(C, D, E, F, G, B)

I.e.
R1(Phone, Q1, Q2, Q3, Q4, Q5)
Key(R1) : A === Phone
Primary Key: A === Phone
Functional Dependencies: A -> CDEFG === Phone -> Q1, Q2, Q3, Q4, Q5

R2(Risk Tolerance, Q1, Q2, Q3, Q4, Q5)
Key(R2) : CDEFG === Q1, Q2, Q3, Q4, Q5
Primary Key: CDEFG === Q1, Q2, Q3, Q4, Q5

Functional Dependencies: CDEFG -> B === Q1, Q2, Q3, Q4, Q5 -> Risk Tolerance

Given that for both R1 and R2, the LHS of each non-trivial FD contains a key of the respective tables, both R1 and R2 are in Boyce-Codd Normal Form and hence 3NF.

STOCK_IN_PORTFOLIO

Let ASSET-ID, Post Trade CO, Phone, PID , Stock ID, Start Date, Allocation Ratio be A,B,C,D,E,F,G respectively

Keys: CDE
Primary Key: CDE
Functional Dependencies: A->B, CDE->AFGB

Inspecting A->B shows that it violates 3NF, as A is not a superkey and B is not a prime attribute.
Hence, we find the minimal basis. Decomposing the FDs to only have a single RHS attribute we get:

{CDE->A, CDE->F, CDE->G, CDE->B, A->B}

From above, we can see that CDE->B is redundant, as CDE->A, A->B (Transitivity Rule).

Next, we inspect if there are any redundant attributes on the LHS of any FD. Upon inspection, there is none – no further amendments needed.

Hence, minimal basis = {CDE-> A, CDE->F, CDE->G, A->B}

Decomposition into two tables containing the attributes of each FD gives us:

R1(C, D, E, A, F, G)
R2(A, B)

I.e. R1(Phone, PID, StockID, ASSET-ID, Start Date, Allocation Ratio)
Key(R1) : CDE == Phone, PID , Stock ID, Start Date
Primary Key: CDE == Phone, PID , Stock ID, Start Date
Functional Dependencies: CDE-> AFG == Phone, PID , Stock ID, Start Date -> ASSET-ID, Start Date, Allocation Ratio

R2(ASSET-ID, Post-Trade CO)
Key(R2) : A == ASSET-ID
Primary Key: ASSET-ID
Functional Dependencies: A->B == ASSET-ID->Post-Trade CO

Given that for both R1 and R2, the LHS of each non-trivial FD contains a key of the respective tables, both R1 and R2 are in Boyce-Codd Normal Form and hence 3NF.

BOND_IN_PORTFOLIO
Let A, B, C, D, E, F, G denote the attributes ASSET-ID, Post-Trade CO, Phone, PID , Bond ID, Start Date, Allocation Ratio respectively.

BOND_IN_PORTFOLIO(A, B, C, D, E, F, G)
Keys: CDE
Primary Key: CDE
Functional Dependencies: A->B, CDE->AFGB

Inspecting A->B shows that it violates 3NF, as A is not a superkey and B is not contained in an attribute
Hence, we find the minimal basis. Decomposing the FDs to only have a single RHS attribute we get:

{ CDE->A, CDE->F, CDE->G, CDE->B, A->B}

From above, we can see that CDE->B is redundant, as CDE->A, A->B (Transitivity Rule).

Next, we inspect if there are any redundant attributes on the LHS of any FD. Upon inspection, there is none – no further amendments needed.

Hence, minimal basis = {CDE-> A, CDE->F, CDE->G, A->B}

Decomposition into two tables containing the attributes of each FD gives us:

R1(C, D, E, A, F, G)
R2(A, B)

I.e.
R1(Phone, PID, Fund ID, ASSET-ID, Start Date, Allocation Ratio)
Key(R1) : CDE == Phone, PID , Bond ID
Primary Key: CDE == Phone, PID , Bond ID
Functional Dependencies: CDE-> AFG == Phone, PID , Bond ID-> ASSET-ID, Start Date, Allocation Ratio

R2(ASSET-ID, Post-Trade CO)
Key(R2) : A == ASSET-ID
Primary Key: ASSET-ID
Functional Dependencies: A->B == ASSET-ID->Post-Trade CO

Given that for both R1 and R2, the LHS of each non-trivial FD contains a key of the respective tables, both R1 and R2 are in Boyce-Codd Normal Form and hence 3NF.

FUND_IN_PORTFOLIO
Let A, B, C, D, E, F, G denote the attributes Phone, PID, FUND-ID, ASSET-ID, Start Date, Allocation Ratio, Post-Trade CO respectively.

FUND_IN_PORTFOLIO(A,B,C,D,E,F,G)

Keys : ABC
Primary Key: ABC
Functional Dependencies: D -> G, ABC->DEFG

Inspecting D->G shows that it violates 3NF, as D is not a superkey and G is not contained in a key.
Hence, we find the minimal basis. Decomposing the FDs to only have a single RHS attribute we get:
{ D->G, ABC->D, ABC->E, ABC->F, ABC->G }

From above, we can see that ABC->G is redundant, as ABC->D and D->G. (Transitivity Rule).

Next, we inspect if there are any redundant attributes on the LHS of any FD. Upon inspection, there is none – no further amendments needed.

Hence, minimal basis = {D->G, ABC->D, ABC->E, ABC->F}

Combining the FDs whose LHS are the same we get:

{D->G, ABC->DEF}

Decomposition into two tables containing the attributes of each FD gives us:
R1(A,B,C,D,E,F)
R2(D,G)

I.e.
R1(Phone, PID, FUND-ID, ASSET-ID, Start Date, Allocation Ratio)
Key(R1) : ABC == Phone, FUND-ID, ASSET-ID
Primary Key(R1) : ABC == Phone, FUND-ID, ASSET-ID
Functional Dependencies: ABC->DEF === Phone, PID, FUND-ID -> ASSET-ID, Start Date, Allocation Ratio

R2(ASSET-ID, Post-Trade CO)
Key(R2): D == ASSET-ID
Primary Key(R2): D == ASSET-ID
Functional Dependencies: D->G == ASSET-ID -> Post-Trade CO

Given that for both R1 and R2, the LHS of each non-trivial FD contains a key of the respective tables, both R1 and R2 are in Boyce-Codd Normal Form and hence 3NF.

Assumptions

- Date includes both date and time such as 28/2/2025 3:20pm, and there exists a time delay between multiple transactions i.e. no transactions in the same portfolio share the same Date value.
- The same asset is always bought from the same Post-Trade CO across investors.