A) How to Represent Sentences Using First-Order Logic (FOL)

First-Order Logic (FOL) ek language hai jisse hum natural language statements ko mathematically likh sakte hain. Yeh exact meaning express karta hai bina confusion ke.

1. Constants (Naam wale log ya cheezein)

Specific entities jinka ek fixed meaning hota hai. Example: Leo, Piano, Guitar, Maya.

2. Variables (x, y, z...)

General placeholders hote hain jo kisi bhi entity ko represent karte hain. Example: x (koi bhi banda), y (koi bhi instrument).

3. Predicates (Properties ya Relations)

Predicates actions ya relations batate hain. Example: Plays(x, y), Owns(x, y), Musician(x).

4. Quantifiers

Universal Quantifier (∀): 'For all' — sab par apply hota hai.
Existential Quantifier (∃): 'There exists' — kam se kam ek exist karta hai.

5. Logical Connectives

Symbol	Meaning	Example	Read As
∧	AND	A ∧ B	A and B dono true
∨	OR	A ∨ B	A ya B true
¬	NOT	¬A	A nahi hai
→	IMPLIES	A → B	A hone par B bhi hoga
↔	IFF	A ↔ B	A tabhi true jab B true

Example:

Sentence: Everyone who plays guitar is a musician.
FOL: ∀x (Plays(x, Guitar) → Musician(x))

B) Assertions in FOL

(a) Leo plays either the piano or the guitar.
FOL: Plays(Leo, Piano) ∨ Plays(Leo, Guitar)

(b) Maya teaches someone who owns a violin.
FOL: ∃x (Teaches(Maya, x) ∧ Owns(x, Violin))

(c) All guitar players are musicians.
FOL: $\forall x$ (Plays(x, Guitar) $\rightarrow$ Musician(x))

(d) Arjun does not play the piano or the violin.
FOL: $\neg$Plays(Arjun, Piano) $\wedge$ $\neg$Plays(Arjun, Violin)

(e) Leo owns every instrument he plays.
FOL: $\forall i$ (Plays(Leo, i) $\rightarrow$ Owns(Leo, i))

(f) There exists a musician who teaches only musicians.
FOL: $\exists p$ (Musician(p) $\wedge$ $\forall q$ (Teaches(p, q) $\rightarrow$ Musician(q)))

(g) Everyone who owns a violin also plays it.
FOL: $\forall p$ (Owns(p, Violin) $\rightarrow$ Plays(p, Violin))

(h) No one teaches themselves.
FOL: $\forall p$ $\neg$Teaches(p, p)

(i) All musicians play at least one instrument.
FOL: $\forall p$ (Musician(p) $\rightarrow$ $\exists i$ Plays(p, i))

(j) There exists a person who plays all instruments.
FOL: $\exists p$ $\forall i$ Plays(p, i)

Quick Exam Summary:

Concept	Symbol / Example	Meaning
Constants	Leo, Piano	Specific entity
Variables	x, y	General placeholder
Predicate	Plays(x, y)	Relation between x and y
$\forall$	Universal Quantifier	For all
$\exists$	Existential Quantifier	There exists
$\wedge$, $\vee$, $\neg$, $\rightarrow$, $\leftrightarrow$	Connectives	And, Or, Not, Implies, If and only if