# Resolution using Predicate Logic in Artificial Intelligence

**1. Was Marcus Loyal to Caesar?**

$$nil$$

$$\downarrow (1)$$

$$man(Marcus)$$

$$\downarrow (9)$$

$$person(Marcus)$$

$$\downarrow (8)$$

$$person(Marcus) \wedge tryassassinate\{Marcus, Caesar\}$$

$$\downarrow (4)$$

$$person(Marcus) \wedge tryassassinate\{Marcus, Caesar\} \wedge ruler(Caesar)$$

$$\downarrow (7,\ \text{substitution})$$

$$\neg\ loyalto(Marcus,\ Caesar)$$

1. $man(Marcus)$
2. $Pompeian(Marcus)$
3. $\forall x : Pompeian(x) \rightarrow Roman(x)$
4. $ruler(Caesar)$
5. $\forall x : Roman(x) \rightarrow loyalto(x, Caesar) \vee hate(x, Caesar)$
6. $\forall x : \exists y : loyalto(x, y)$
7. $\forall x : \forall y : person(x) \wedge ruler(y) \wedge tryassassinate(x, y) \rightarrow \neg loyalto(x, y)$
8. $tryassassinate(Marcus, Caesar)$
9. $\forall x : man(x) \rightarrow person(x)$

# Resolution using Predicate Logic in Artificial Intelligence

**2. Was Marcus hates Caesar?**

$\neg$ *loyalto*(*Marcus*, *Caesar*)

↓ (2)

*Pompeian*(*Marcus*)

$\neg$ *loyalto*(*Marcus*, *Caesar*)

↓ (3)

*Roman*(*Marcus*)

$\neg$ *loyalto*(*Marcus*, *Caesar*)

↓ (5)

*hate*(*Marcus*, *Caesar*)

1. $man(Marcus)$
2. $Pompeian(Marcus)$
3. $\forall x : Pompeian(x) \rightarrow Roman(x)$
4. $ruler(Caesar)$
5. $\forall x : Roman(x) \rightarrow loyalto(x, Caesar) \vee hate(x, Caesar)$
6. $\forall x : \exists y : loyalto(x, y)$
7. $\forall x : \forall y : person(x) \wedge ruler(y) \wedge tryassassinate(x, y) \rightarrow \neg loyalto(x, y)$
8. $tryassassinate(Marcus, Caesar)$
9. $\forall x : man(x) \rightarrow person(x)$

# Facts to First Order Logic (FOL) in Artificial Intelligence

a. John likes all kind of food.

b. Apple and vegetable are food

c. Anything anyone eats and not killed is food.

d. Anil eats peanuts and still alive

e. Harry eats everything that Anil eats.

f. John likes peanuts.

a. $\forall x: food(x) \rightarrow likes(John, x)$

b. $food(Apple) \land food(vegetables)$

c. $\forall x \forall y: eats(x, y) \land \neg killed(x) \rightarrow food(y)$

d. $eats(Anil, Peanuts) \land alive(Anil)$.

e. $\forall x : eats(Anil, x) \rightarrow eats(Harry, x)$

f. $\forall x: \neg killed(x) \rightarrow alive(x)$ } added predicates

g. $\forall x: alive(x) \rightarrow \neg killed(x)$ }

h. $likes(John, Peanuts)$

# First Order Logic to Conjunctive Normal Form

- **Eliminate all implication (→) and rewrite**

a. ∀x: food(x) → likes(John, x)

b. food(Apple) ∧ food(vegetables)

c. ∀x ∀y: eats(x, y) ∧ ¬ killed(x) → food(y)

d. eats (Anil, Peanuts) ∧ alive(Anil).

e. ∀x : eats(Anil, x) → eats(Harry, x)

f. ∀x: ¬ killed(x) → alive(x)

g. ∀x: alive(x) →¬ killed(x)

h. likes(John, Peanuts)

a. ∀x ¬ food(x) V likes(John, x)

b. food(Apple) ∧ food(vegetables)

d. ∀x ∀y ¬ [eats(x, y) ∧ ¬ killed(x)] V food(y)

d. eats (Anil, Peanuts) ∧ alive(Anil)

e. ∀x ¬ eats(Anil, x) V eats(Harry, x)

f. ∀x¬ [¬ killed(x) ] V alive(x)

g. ∀x ¬ alive(x) V ¬ killed(x)

h. likes(John, Peanuts).

# First Order Logic to Conjunctive Normal Form

- **Move negation (¬)inwards and rewrite**

a. $\forall x \neg food(x) \vee likes(John, x)$

b. $food(Apple) \wedge food(vegetables)$

c. $\forall x \forall y \neg [eats(x, y) \wedge \neg killed(x)] \vee food(y)$

d. $eats(Anil, Peanuts) \wedge alive(Anil)$

e. $\forall x \neg eats(Anil, x) \vee eats(Harry, x)$

f. $\forall x \neg [\neg killed(x)] \vee alive(x)$

g. $\forall x \neg alive(x) \vee \neg killed(x)$

h. $likes(John, Peanuts)$.


a. $\forall x \neg food(x) \vee likes(John, x)$

b. $food(Apple) \wedge food(vegetables)$

c. $\forall x \forall y \neg eats(x, y) \vee killed(x) \vee food(y)$

d. $eats(Anil, Peanuts) \wedge alive(Anil)$

e. $\forall x \neg eats(Anil, x) \vee eats(Harry, x)$

f. $\forall x \; killed(x)] \vee alive(x)$

g. $\forall x \neg alive(x) \vee \neg killed(x)$

h. $likes(John, Peanuts)$.

# First Order Logic to Conjunctive Normal Form

- **Rename variables or standardize variables**

a. ∀x ¬ food(x) V likes(John, x)

b. food(Apple) Λ food(vegetables)

c. ∀x ∀y ¬ eats(x, y) V killed(x) V food(y)

d. eats (Anil, Peanuts) Λ alive(Anil)

e. ∀x ¬ eats(Anil, x) V eats(Harry, x)

f. ∀x killed(x) ] V alive(x)

g. ∀x ¬ alive(x) V ¬ killed(x)

h. likes(John, Peanuts).

a. ∀x ¬ food(x) V likes(John, x)

b. food(Apple) Λ food(vegetables)

c. ∀y ∀z ¬ eats(y, z) V killed(y) V food(z)

d. eats (Anil, Peanuts) Λ alive(Anil)

e. ∀w¬ eats(Anil, w) V eats(Harry, w)

f. ∀g killed(g) ] V alive(g)

g. ∀k ¬ alive(k) V ¬ killed(k)

h. likes(John, Peanuts).

# First Order Logic to Conjunctive Normal Form

- **Drop Universal quantifiers.**

a. ∀x ¬ food(x) V likes(John, x)

b. food(Apple) Λ food(vegetables)

c. ∀y ∀z ¬ eats(y, z) V killed(y) V food(z)

d. eats (Anil, Peanuts) Λ alive(Anil)

e. ∀w¬ eats(Anil, w) V eats(Harry, w)

f. ∀g killed(g) ] V alive(g)

g. ∀k ¬ alive(k) V ¬ killed(k)

h. likes(John, Peanuts).

a. ¬ food(x) V likes(John, x)

b. food(Apple)

c. food(vegetables)

d. ¬ eats(y, z) V killed(y) V food(z)

e. eats (Anil, Peanuts)

f. alive(Anil)

g. ¬ eats(Anil, w) V eats(Harry, w)

h. killed(g) V alive(g)

i. ¬ alive(k) V ¬ killed(k)

j. likes(John, Peanuts).

# Draw Resolution Tree in Artificial Intelligence

a. ¬ food(x) V likes(John, x)

b. food(Apple)

c. food(vegetables)

d. ¬ eats(y, z) V killed(y) V food(z)

e. eats (Anil, Peanuts)

f. alive(Anil)

g. ¬ eats(Anil, w) V eats(Harry, w)

h. killed(g) V alive(g)

i. ¬ alive(k) V ¬ killed(k)

j. likes(John, Peanuts).