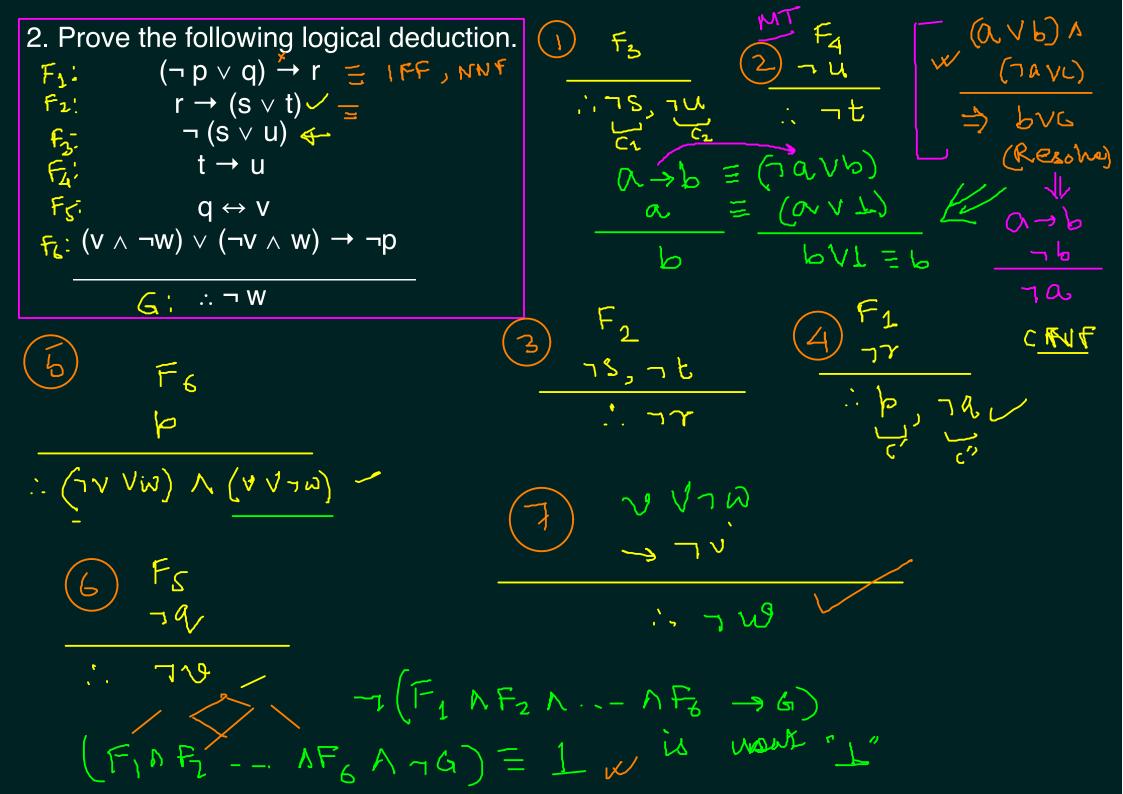
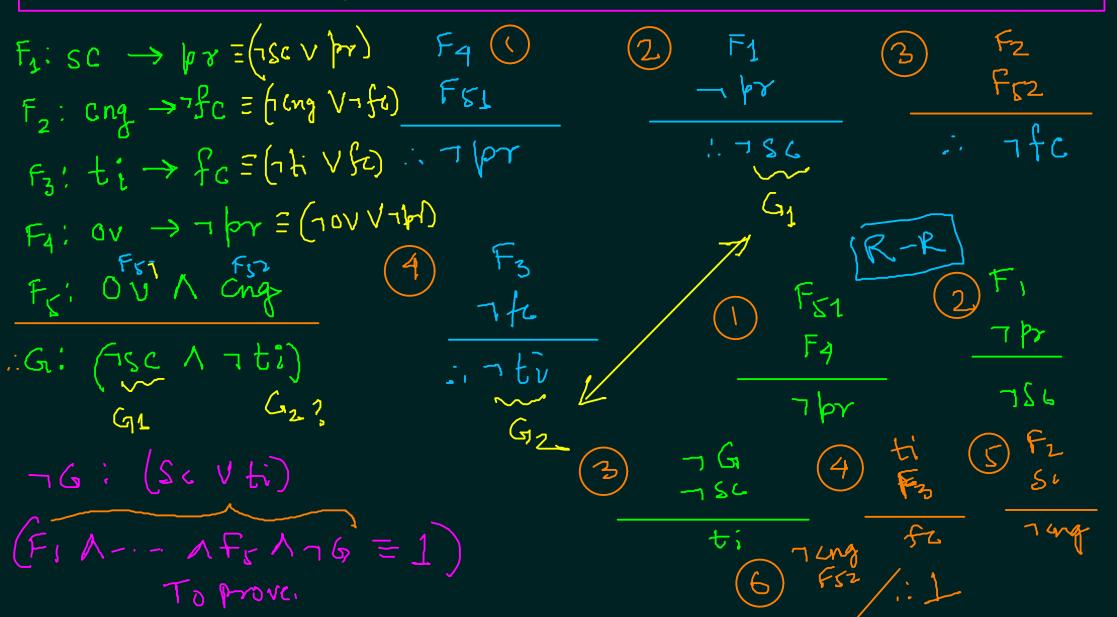
- 1. Which of the following sentences are valid (tautology), unsatisfiable, or neither.
 - (a) (Smoke \rightarrow Fire) \rightarrow (\neg Smoke $\rightarrow \neg$ Fire)
 - (b) (Smoke \rightarrow Fire) \rightarrow ((Smoke \land Heat) \rightarrow Fire)



3. Encode and reason about the following. If a scarcity of commodities develops, then the prices rise. If there is a change of government, then fiscal controls will not be continued. If the threat of inflation persists, then fiscal controls will be continued. If there is over-production, then prices do not rise. It has been found that there is over-production and there is a change of government. Therefore, neither the scarcity of commidities has developed, nor there is a threat of inflation.



4. Prove that,
$$\forall x [P(x) \rightarrow (Q(x) \leftrightarrow R(x))]$$
 is equivalent to
$$[\forall x [(P(x) \land Q(x)) \rightarrow R(x)]] \land [\forall x [(P(x) \land R(x)) \rightarrow Q(x)]]$$

$$(S_{3} \leftrightarrow S_{2}) = \underbrace{\exists}_{T_{1}} \underbrace{\exists}_{S_{2}} \underbrace{S_{1}}_{S_{1}} \underbrace{\exists}_{T_{2}} \underbrace{\exists}_{S_{1}} \underbrace$$

5.	. Formalize the following sentences	in first-order logic using only t	he follwoing predicates.
	inside(x, y) : x is inside of y	free(x) : x is free	
	love(x, y) : x loves y	diff(x, y): x differs from y	ر ۸ ۸ ۸
			exactry
	(a) There is at least one person wh	io loves Mary.	me are serious

(b) There is exactly one person who loves Mary. (c) There is at most one person who loves Mary.

(a) $\exists x \text{ love } (x, Many)$ (b) $\exists x \text{ love } (x, Many) \land \forall y (\text{diff}(x,y)) \rightarrow \neg \text{ love}(y, Many)$ $\forall y \text{ love } (y, Many) \rightarrow \neg \text{ diff}(x,y))$ (c) $[b] \lor [\forall y \neg \text{ love}(y, Many)]$

6. Translate the following into idiomatic/concise English statement: $\forall x [[H(x) \land \forall y \neg M(x, y)] \rightarrow U(x)]$, where H(x): x is a man, M(x, y): x is married to y, U(x): x is unhappy, and x and y range over people.

La All unmarried men are unhappy-

7. Encode the following logical statements using predicate logic (formulate suitable predicate and function symbols as required), and conclude on the validity of the last statement.

No man who is a candidate will be defeated if he is a good campaigner. Any man who runs for office is a candidate. Any candidate who is not defeated will be elected. Every man who is elected is a good campaigner. Therefore, Any man who runs for office will be elected if and only if he is a good campaigner.

$$F_1: \forall x \left[(\text{cand}(x) \land \text{camp}(x)) \rightarrow \neg \text{def}(x) \right] \qquad \text{cand}(x)$$

$$F_2: \forall x \left[\text{off}(x) \rightarrow \text{cand}(x) \right] \qquad \text{camp}(x)$$

$$F_3: \forall x \left[(\text{cand}(x) \land \neg \text{def}(x)) \rightarrow \text{elec}(x) \right] \qquad \text{off}(x)$$

$$F_4: \forall x \left[\text{elec}(x) \rightarrow \text{camp}(x) \right]$$

$$G: \forall x \left[\text{off}(x) \rightarrow \left(\text{elec}(x) \leftrightarrow \text{camp}(x) \right) \right] = G_1 \land G_2$$

$$G_1: \forall x \left[(\text{off}(x) \land \text{elec}(x)) \rightarrow \text{camp}(x) \right] \rightarrow \text{elec}(x)$$

$$G_2: \forall x \left[(\text{off}(x) \land \text{elec}(x)) \rightarrow \text{camp}(x) \right] \rightarrow \text{elec}(x)$$

Fi: (Toand (a) V Toamp(x) V Tdeffor) C1 G = G, N G2 Fz: (70ff(n) V cand (n)) Cz : 7 G = (1 G1 V7G2) Fz: (7 Canil (n) V det (n) V electha) (z CNF Cy & G ---Fy: (7 elec(n) > Camp(n)) (4) 7 Gz: Fx [off (A) 1 camb(A) 17elec (A)] 7(97: Jul offly velec(4) VI campch) G11 G12 G13 FIN X/A Resolution Refut. $\rightarrow 1$