Introduction to Logic

PHIL 170

Eric Pacuit

University of Maryland, College Park
pacuit.org
epacuit@umd.edu

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Announcements

- Good job on the Midterm!
- Make sure that you can solve the problems on paper!
- Summary of grades will be emailed/added to ELMS
- Quiz due on Friday, Lab due on Sunday.
- Watch for more videos about how to do the upcoming problems on LogicLab...
- **Email**: You should email your TA first with questions about extensions, problems with the assignments, etc.

Fun problems to think about...

Imagine you have been transported to the mysterious "Island of Knights and Knaves" where every inhabitant is either a knight or a knave. Every knight always tells the truth and every knave always lies.

You stop for gas and the attendant says, "Either I am a knight or I am not a knight." What is he?

Suppose that you see two people A and B. Suppose that A says "Either I am a knave or B is a knight." What can you conclude?

Suppose that A says "Either I am a knave or $2 + 2 = 5$." What can you conclude?

Fun problems to think about...

An advertisement for a tennis magazine states, "If I'm not playing tennis, I'm watching tennis. And if I'm not watching tennis, I'm reading about tennis." We can assume that the speaker cannot do more than one of these activities at a time. What is the speaker doing?

General Observations

$$\begin{array}{c} \varphi_1 \\ \varphi_2 \\ \vdots \\ \varphi_n \\ \hline \therefore \psi \end{array}$$ is valid if, and only if, $((\varphi_1 \;\&\; \varphi_2 \;\&\; \cdots \;\&\; \varphi_n) \to \psi)$ is a tautology.

φ and ψ are **logically equivalent** (i.e., have exactly the same truth-values) if, and only if, $((\varphi \to \psi) \;\&\; (\psi \to \varphi))$ is a tautology.

We often write $\varphi \leftrightarrow \psi$ for $((\varphi \to \psi) \;\&\; (\psi \to \varphi))$

Logical Equivalences

$\varphi \to \psi$	$\neg\varphi \vee \psi$
$\varphi \to \psi$	$\neg(\varphi \wedge \neg\psi)$
$\varphi \to \psi$	$\neg\psi \to \neg\varphi$
$\neg(\varphi \vee \psi)$	$(\neg\varphi \,\&\, \neg\psi)$
$\neg(\varphi \,\&\, \psi)$	$(\neg\varphi \vee \neg\psi)$
$\neg\neg\varphi$	φ
$(\varphi \,\&\, (\psi \vee \chi))$	$((\varphi \,\&\, \psi) \vee (\varphi \,\&\, \chi))$
$(\varphi \vee (\psi \,\&\, \chi))$	$((\varphi \vee \psi) \,\&\, (\varphi \vee \chi))$
$(\varphi \to (\psi \to \chi))$	$((\varphi \,\&\, \psi) \to \chi)$

Questions

Why are we learning both truth-tables *and* truth-trees?

Why does LogicLab force you to enter truth-value assignments in the way that it does?

What's next?

Questions

Why are we learning both truth-tables *and* truth-trees?

Why does LogicLab force you to enter truth-value assignments in the way that it does?

What's next? Deductions

Arguments

I need to be at UMD by 11am.

Lily needs to be at the bus-stop by 9am.

Arguments

✗ I need to be at UMD by 11am.
Lily needs to be at the bus-stop by 9am.

Ann brought here laptop to first three lectures.
Ann will bring her laptop to today's lecture.

Arguments

✗ I need to be at UMD by 11am.
Lily needs to be at the bus-stop by 9am.

Ann brought here laptop to first three lectures.
Ann will bring her laptop to today's lecture.

Bob is a bachelor.
Bob is unmarried.

Arguments

✗ I need to be at UMD by 11am.
Lily needs to be at the bus-stop by 9am.

Ann brought here laptop to first three lectures.
Ann will bring her laptop to today's lecture.

Bob is a bachelor.
Bob is unmarried.

Ann will have salad or steak.
Ann will not have steak.
Ann will have salad.

Arguments

✗ I need to be at UMD by 11am.
Lily needs to be at the bus-stop by 9am.

✗ Ann brought here laptop to first three lectures.
Ann will bring her laptop to today's lecture.

✗ Bob is a bachelor.
Bob is unmarried.

✓ Ann will have salad or steak.
Ann will not have steak.
Ann will have salad.

Arguments

✗ $$\frac{U}{\therefore L}$$

✗ $$\frac{((L_1 \mathbin{\&} L_2) \mathbin{\&} L_3)}{\therefore L_4}$$

✗ $$\frac{B(b)}{\therefore U(b)}$$

✓ $$\begin{array}{l} A \vee S \\ \neg S \\ \hline \therefore A \end{array}$$

Deductions

An advertisement for a tennis magazine states, "If I'm not playing tennis, I'm watching tennis. And if I'm not watching tennis, I'm reading about tennis." We can assume that the speaker cannot do more than one of these activities at a time. What is the speaker doing?

Deductions

An advertisement for a tennis magazine states, "If I'm not playing tennis, I'm watching tennis. And if I'm not watching tennis, I'm reading about tennis." We can assume that the speaker cannot do more than one of these activities at a time. What is the speaker doing?

$$
\begin{array}{l}
\neg P \rightarrow W \\
\neg W \rightarrow R \\
((P \vee W) \vee R) \\
(P \rightarrow (\neg W \ \& \ \neg R)) \\
(R \rightarrow (\neg P \ \& \ \neg W)) \\
(W \rightarrow (\neg P \ \& \ \neg R)) \\
\hline
\therefore R
\end{array}
$$

Deductions

1.	$\neg P \to W$	Premise
2.	$\neg W \to R$	Premise
3.	$(P \to (\neg W \ \& \ \neg R))$	Premise
4.	$(R \to (\neg P \ \& \ \neg W))$	Premise
5.	$(W \to (\neg P \ \& \ \neg R))$	Premise
	$\vdots$	
c.	W	Goal

Conjunction Introduction (&I)

$p1.$	φ	
$p2.$	ψ	
	$\vdots$	
c.	$(\varphi \mathbin{\&} \psi)$	&I: $p1, p2$

Conjunction Introduction (&I)

1.	A	Premise
2.	B	Premise
3.	$(A \,\&\, (B \vee C))$	Premise

Conjunction Introduction (&I)

1.	A	Premise
2.	B	Premise
3.	$(A \mathbin{\&} (B \vee C))$	Premise
4.	$(A \mathbin{\&} B)$	&I : 1, 2

Conjunction Introduction (&I)

1.	A	Premise
2.	B	Premise
3.	$(A \mathbin{\&} (B \vee C))$	Premise
4.	$(A \mathbin{\&} B)$	&I : 1, 2
5.	$(B \mathbin{\&} A)$	&I : 2, 1

Conjunction Introduction (&I)

1.	A	Premise
2.	B	Premise
3.	$(A \,\&\, (B \vee C))$	Premise
4.	$(A \,\&\, B)$	&I : 1, 2
5.	$(B \,\&\, A)$	&I : 2, 1
6.	$(A \,\&\, A)$	&I : 1, 1

Conjunction Introduction (&I)

1.	A	Premise
2.	B	Premise
3.	$(A \mathbin{\&} (B \vee C))$	Premise
4.	$(A \mathbin{\&} B)$	&I : 1, 2
5.	$(B \mathbin{\&} A)$	&I : 2, 1
6.	$(A \mathbin{\&} A)$	&I : 1, 1

Conjunction Introduction (&I)

1.	A	Premise
2.	B	Premise
3.	$(A \,\&\, (B \vee C))$	Premise
4.	$(A \,\&\, B)$	&I : 1, 2
5.	$(B \,\&\, A)$	&I : 2, 1
6.	$(A \,\&\, A)$	&I : 1, 1
7.	$((A \,\&\, (B \vee C)) \,\&\, B)$	&I : 3, 2

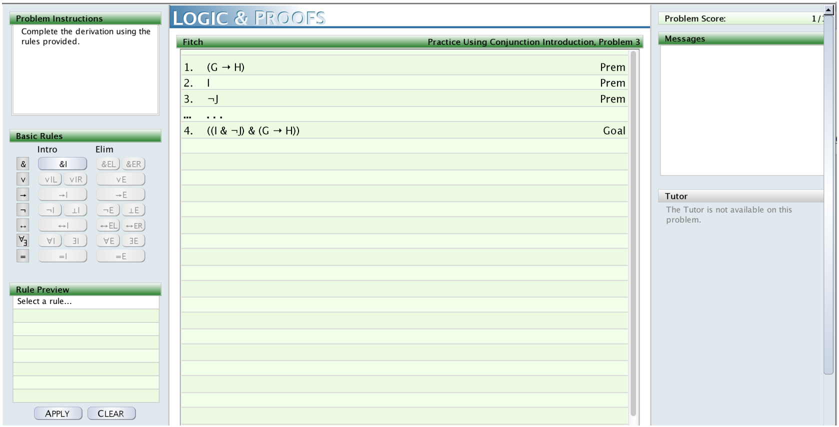
Conjunction Introduction (&I)

1.	A	Premise
2.	B	Premise
3.	$(A \,\&\, (B \vee C))$	Premise
4.	$(A \,\&\, B)$	$\&\mathrm{I} : 1, 2$
5.	$(B \,\&\, A)$	$\&\mathrm{I} : 2, 1$
6.	$(A \,\&\, A)$	$\&\mathrm{I} : 1, 1$
7.	$((A \,\&\, (B \vee C)) \,\&\, B)$	$\&\mathrm{I} : 3, 2$
8.	$((B \,\&\, A) \,\&\, (A \,\&\, A))$	$\&\mathrm{I} : 5, 6$

Example

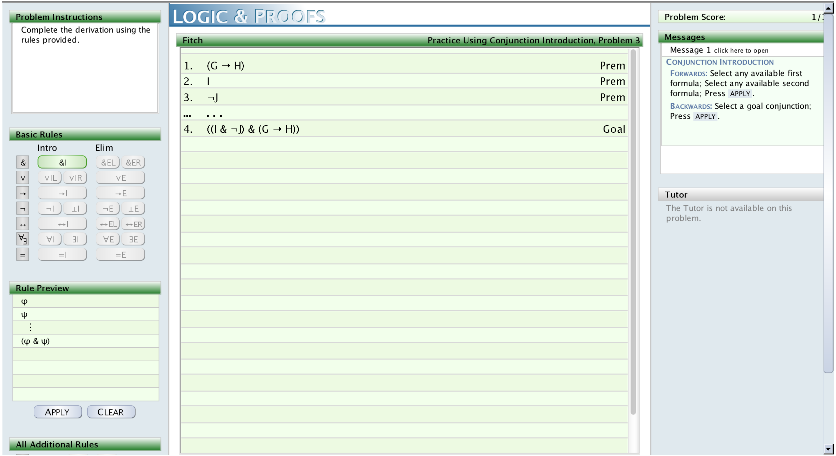
1.	$(G \to H)$	Premise
2.	I	Premise
3.	$\neg J$	Premise
$\vdots$		
n.	$((I \,\&\, \neg J) \,\&\, (G \to H))$	Goal

Example



Problem Instructions
Complete the derivation using the rules provided.
Basic Rules
Intro
Elim
Rule Preview
Select a rule...
APPLY
CLEAR
LOGIC & PROOFS
Fitch
Practice Using Conjunction Introduction, Problem 3
1. (G → H) Prem
2. I Prem
3. ¬J Prem
4. ((I & ¬J) & (G → H)) Goal
Problem Score:
Messages
Tutor
The Tutor is not available on this problem.

Example


Problem Instructions
Complete the derivation using the rules provided.
Basic Rules
Intro
Elim
Rule Preview
φ
ψ
(φ & ψ)
APPLY
CLEAR
All Additional Rules
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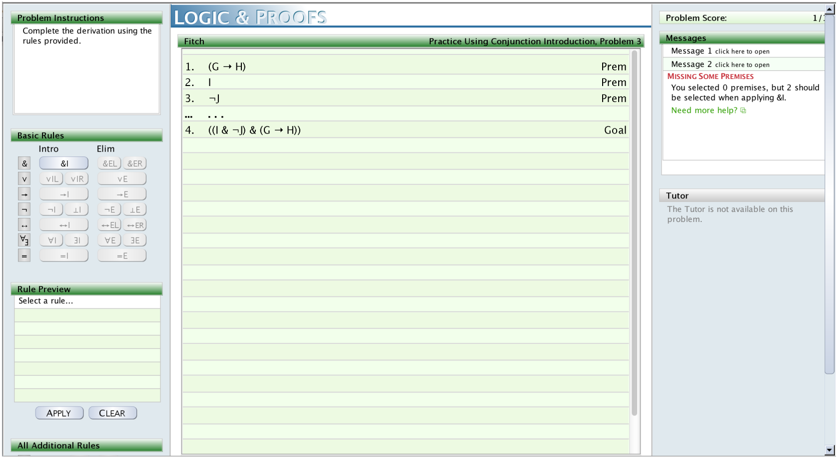
Practice Using Conjunction Introduction, Problem 3
1. (G → H) Prem
2. I Prem
3. ¬J Prem
4. ((I & ¬J) & (G → H)) Goal
Problem Score:
Messages
Message 1 click here to open
CONJUNCTION INTRODUCTION
FORWARDS: Select any available first formula; Select any available second formula; Press APPLY.
BACKWARDS: Select a goal conjunction; Press APPLY.
Tutor
The Tutor is not available on this problem.

Example


Problem Instructions
Complete the derivation using the rules provided.
Basic Rules
Intro
Elim
&I
&EL
&ER
∨IL
∨IR
∨E
→I
→E
¬I
⊥I
¬E
⊥E
↔I
↔EL
↔ER
∀I
∃I
∀E
∃E
=I
=E
Rule Preview
Select a rule...
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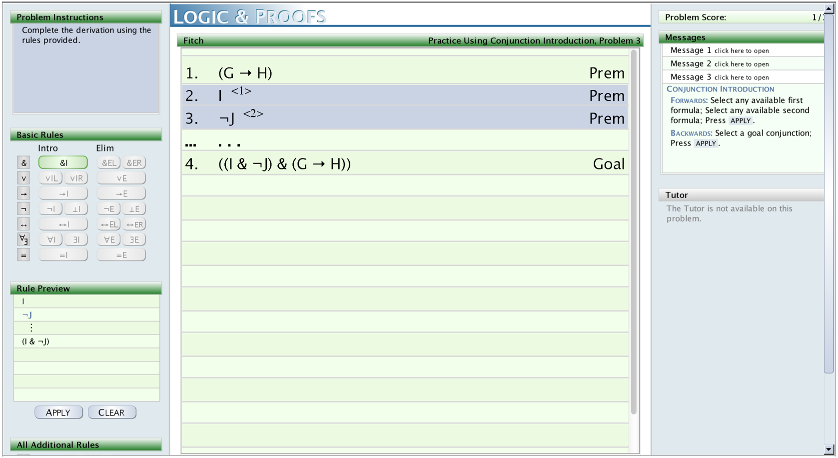
1. (G → H) Prem
2. I Prem
3. ¬J Prem
... . . .
4. ((I & ¬J) & (G → H)) Goal
Problem Score:
Messages
Message 1 click here to open
Message 2 click here to open
MISSING SOME PREMISES
You selected 0 premises, but 2 should be selected when applying &I.
Need more help?
Tutor
The Tutor is not available on this problem.

Example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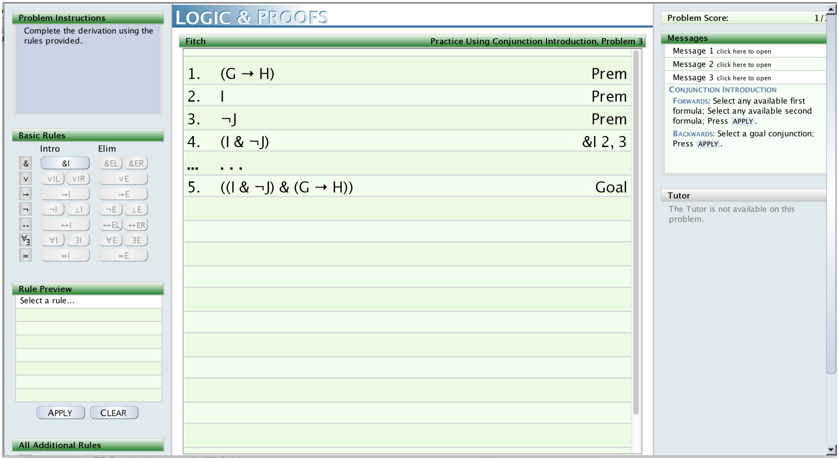
↔EL
↔ER
∀I
∃I
∀E
∃E
=I
=E
Rule Preview
I
¬J
⋮
(I & ¬J)
APPLY
CLEAR
All Additional Rules
LOGIC & PROOFS
Fitch
Practice Using Conjunction Introduction, Problem 3
1. (G → H) Prem
2. I <1> Prem
3. ¬J <2> Prem
... . . .
4. ((I & ¬J) & (G → H)) Goal
Problem Score:
Messages
Message 1 click here to open
Message 2 click here to open
Message 3 click here to open
CONJUNCTION INTRODUCTION
FORWARDS: Select any available first formula; Select any available second formula; Press APPLY.
BACKWARDS: Select a goal conjunction; Press APPLY.
Tutor
The Tutor is not available on this problem.

Example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1. (G → H) Prem
2. I Prem
3. ¬J Prem
4. (I & ¬J) &I 2, 3
5. ((I & ¬J) & (G → H)) Goal
Problem Score:
Messages
Message 1 click here to open
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Message 3 click here to open
Conjunction Introduction
Forwards: Select any available first formula; Select any available second formula; Press APPLY.
Backwards: Select a goal conjunction; Press APPLY.
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Example

1.	$(G \to H)$	Premise
2.	I	Premise
3.	$\neg J$	Premise
5.	$((I \,\&\, \neg J) \,\&\, (G \to H))$	Goal

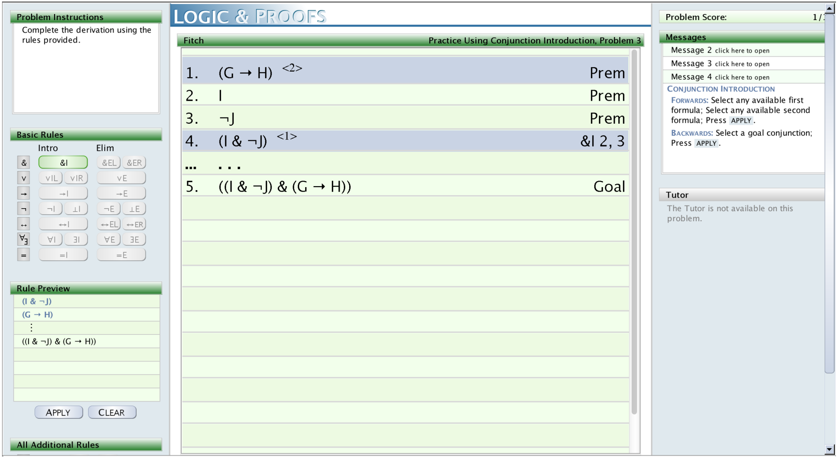
Example

1.	$(G \rightarrow H)$	Premise
2.	I	Premise
3.	$\neg J$	Premise
4.	$(I \ \& \ \neg J)$	&I : 2, 3
5.	$((I \ \& \ \neg J) \ \& \ (G \rightarrow H))$	Goal

Example

1.	$(G \to H)$	Premise
2.	I	Premise
3.	$\neg J$	Premise
4.	$(I \mathbin{\&} \neg J)$	$\&$I : 2, 3
5.	$((I \mathbin{\&} \neg J) \mathbin{\&} (G \to H))$	$\&$I : 4, 1

Example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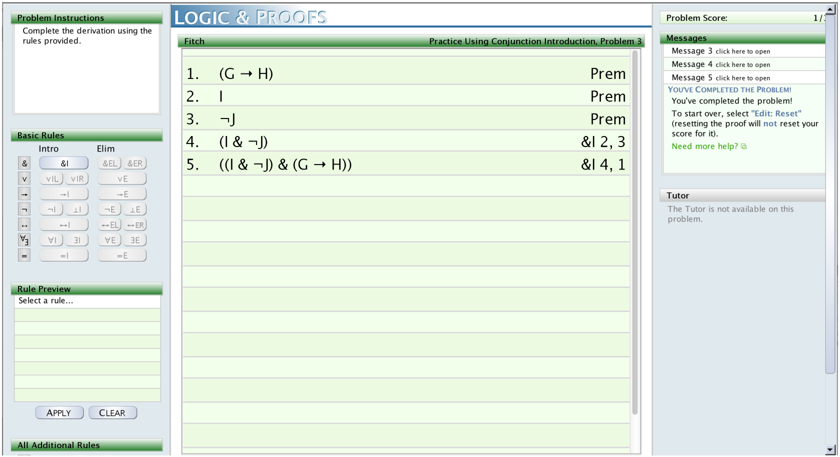
Rule Preview
(I & ¬J)
(G → H)
((I & ¬J) & (G → H))
APPLY
CLEAR
All Additional Rules
LOGIC & PROOFS
Fitch
Practice Using Conjunction Introduction, Problem 3
1. (G → H) <2> Prem
2. I Prem
3. ¬J Prem
4. (I & ¬J) <1> &I 2, 3
5. ((I & ¬J) & (G → H)) Goal
Problem Score:
Messages
Message 2 click here to open
Message 3 click here to open
Message 4 click here to open
CONJUNCTION INTRODUCTION
FORWARDS: Select any available first formula; Select any available second formula; Press APPLY.
BACKWARDS: Select a goal conjunction; Press APPLY.
Tutor
The Tutor is not available on this problem.

Example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=I
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Rule Preview
Select a rule...
APPLY
CLEAR
All Additional Rules
LOGIC & PROOFS
Fitch
Practice Using Conjunction Introduction, Problem 3
1. (G → H) Prem
2. I Prem
3. ¬J Prem
4. (I & ¬J) &I 2, 3
5. ((I & ¬J) & (G → H)) &I 4, 1
Problem Score:
Messages
Message 3 click here to open
Message 4 click here to open
Message 5 click here to open
YOU'VE COMPLETED THE PROBLEM!
You've completed the problem!
To start over, select "Edit: Reset" (resetting the proof will not reset your score for it).
Need more help?
Tutor
The Tutor is not available on this problem.

Conjunction Elimination (&EL, &ER)

$p1.$	$(\varphi \,\&\, \psi)$	
	$\vdots$	
c.	φ	&EL : $p1$

$p1.$	$(\varphi \,\&\, \psi)$	
	$\vdots$	
c.	ψ	&ER : $p1$

Conjunction Elimination (&EL, &ER)

1.	$((A \mathbin{\&} (B \vee C)) \mathbin{\&} D)$	Premise

Conjunction Elimination (&EL, &ER)

1.	$((A \,\&\, (B \vee C)) \,\&\, D)$	Premise
2.	D	&ER : 1

Conjunction Elimination (&EL, &ER)

1.	$((A \,\&\, (B \vee C)) \,\&\, D)$	Premise
2.	D	&ER : 1
3.	$(A \,\&\, (B \vee C))$	&EL : 1

Conjunction Elimination (&EL, &ER)

1.	$((A \,\&\, (B \vee C)) \,\&\, D)$	Premise
2.	D	&ER : 1
3.	$(A \,\&\, (B \vee C))$	&EL : 1
4.	A	&EL : 3

Conjunction Elimination (&EL, &ER)

1.	$((A \,\&\, (B \vee C)) \,\&\, D)$	Premise
2.	D	&ER : 1
3.	$(A \,\&\, (B \vee C))$	&EL : 1
4.	A	&EL : 3
5.	$(B \vee C)$	&ER : 3

Example

1.	$(D \mathbin{\&} E)$	Premise
2.	$(F \mathbin{\&} G)$	Premise
5.	$(E \mathbin{\&} F)$	Goal

Example

1.	$(D \mathbin{\&} E)$	Premise
2.	$(F \mathbin{\&} G)$	Premise
3.	F	&EL : 2
5.	$(E \mathbin{\&} F)$	Goal

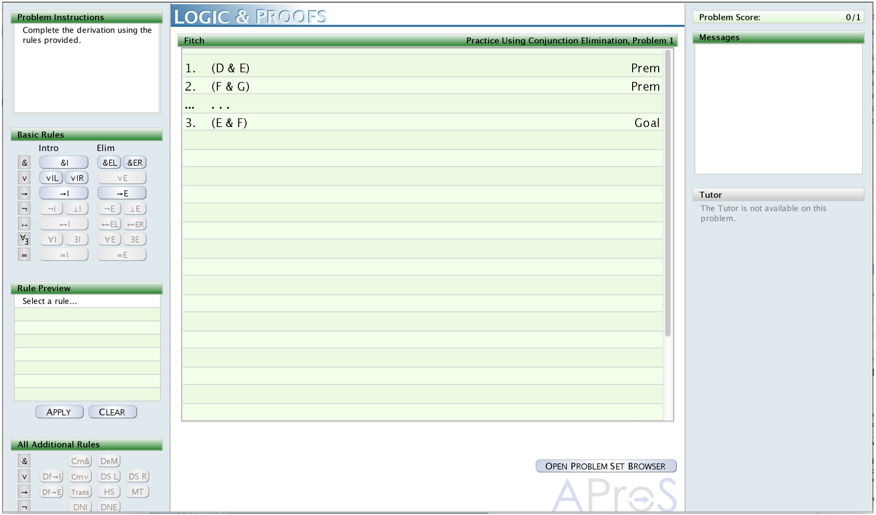
Example

1.	$(D \,\&\, E)$	Premise
2.	$(F \,\&\, G)$	Premise
3.	F	&EL : 2
4.	E	&ER : 1
5.	$(E \,\&\, F)$	Goal

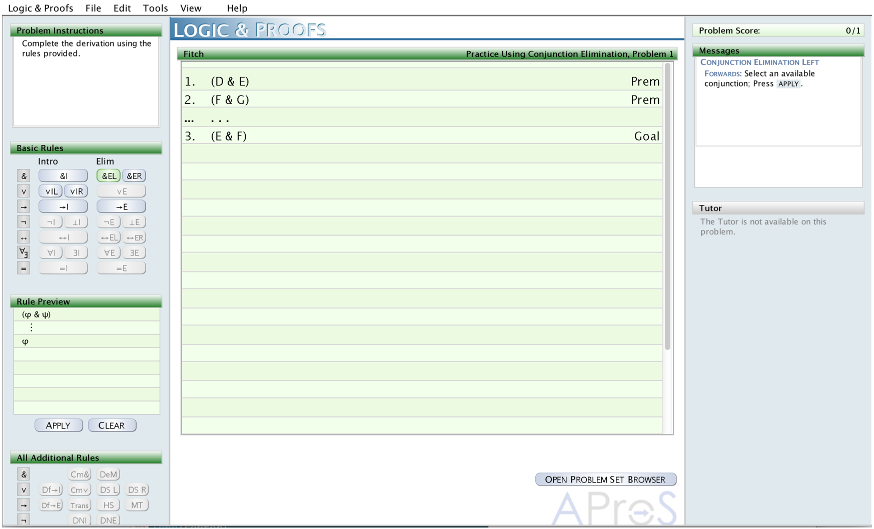
Example

1.	$(D \mathbin{\&} E)$	Premise
2.	$(F \mathbin{\&} G)$	Premise
3.	F	&EL : 2
4.	E	&ER : 1
5.	$(E \mathbin{\&} F)$	&I : 4, 3

Example

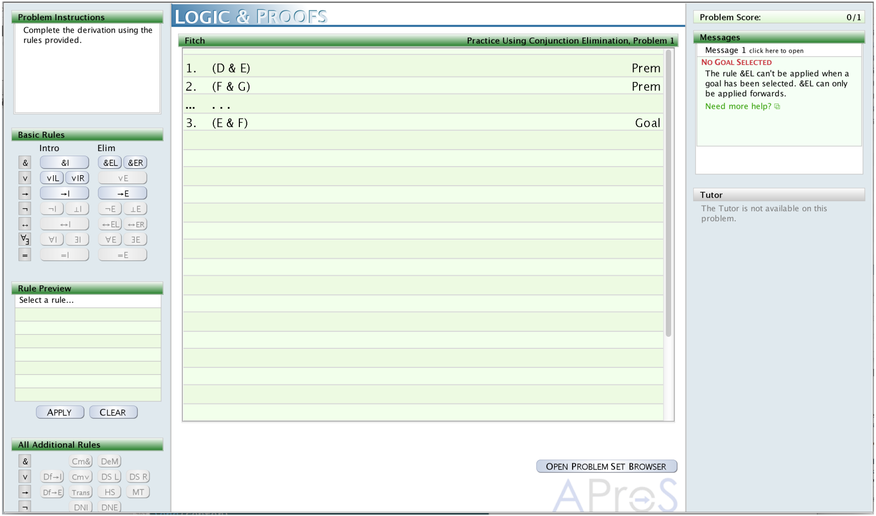

Problem Instructions
Complete the derivation using the rules provided.
Basic Rules
Intro
Elim
Rule Preview
Select a rule...
APPLY
CLEAR
All Additional Rules
LOGIC & PROOFS
Fitch
Practice Using Conjunction Elimination, Problem 1
1. (D & E) Prem
2. (F & G) Prem
... . . .
3. (E & F) Goal
OPEN PROBLEM SET BROWSER
Problem Score: 0/1
Messages
Tutor
The Tutor is not available on this problem.

Example



Logic & Proofs File Edit Tools View Help
LOGIC & PROOFS
Problem Instructions
Complete the derivation using the rules provided.
Basic Rules
Intro
Elim
&I &EL &ER
∨IL ∨IR ∨E
→I →E
¬I ⊥I ¬E ⊥E
↔I ↔EL ↔ER
∀I ∃I ∀E ∃E
=I =E
Rule Preview
(φ & ψ)
⋮
φ
APPLY CLEAR
All Additional Rules
Cm& DeM
Df→I Cm∨ DS L DS R
Df→E Trans HS MT
DNI DNE
Fitch
Practice Using Conjunction Elimination, Problem 1
1. (D & E) Prem
2. (F & G) Prem
... . . .
3. (E & F) Goal
OPEN PROBLEM SET BROWSER
AProS
Problem Score: 0/1
Messages
CONJUNCTION ELIMINATION LEFT
FORWARDS: Select an available conjunction; Press APPLY.
Tutor
The Tutor is not available on this problem.

Example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Complete the derivation using the rules provided.
LOGIC & PROOFS
Fitch
Practice Using Conjunction Elimination, Problem 1
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... . . .
3. (E & F) Goal
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↔ER
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∃I
∀E
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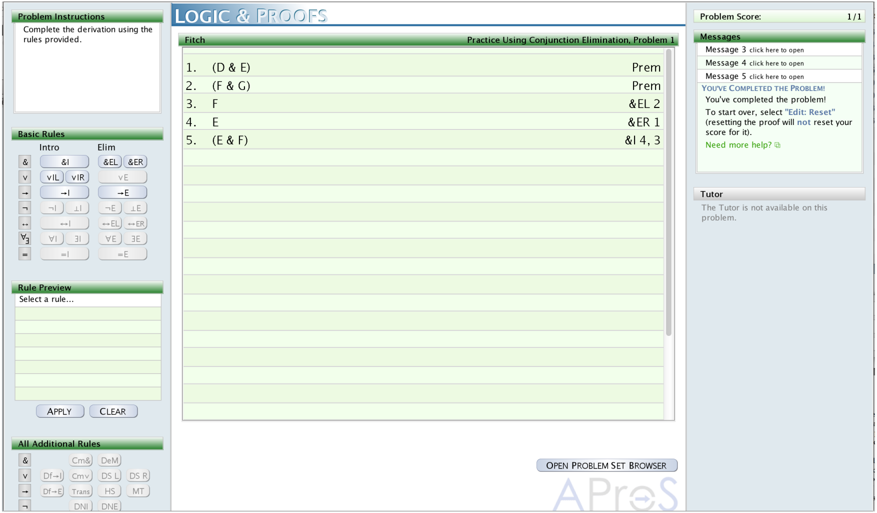
=I
=E
Rule Preview
Select a rule...
APPLY
CLEAR
All Additional Rules
Cm&
DeM
Df→I
Cm∨
DS L
DS R
Df→E
Trans
HS
MT
DNI
DNE
Problem Score: 0/1
Messages
Message 1 click here to open
NO GOAL SELECTED
The rule &EL can't be applied when a goal has been selected. &EL can only be applied forwards.
Need more help?
Tutor
The Tutor is not available on this problem.
OPEN PROBLEM SET BROWSER
AProS

Example


Problem Instructions
Complete the derivation using the rules provided.
Basic Rules
Intro
Elim
Rule Preview
(F & G)
⋮
F
APPLY
CLEAR
All Additional Rules
LOGIC & PROOFS
Fitch
Practice Using Conjunction Elimination, Problem 1
1. (D & E) Prem
2. (F & G) <1> Prem
... . . .
3. (E & F) Goal
OPEN PROBLEM SET BROWSER
APros
Problem Score: 0/1
Messages
Message 1 click here to open
Message 2 click here to open
CONJUNCTION ELIMINATION LEFT
FORWARDS: Select an available conjunction; Press APPLY.
Tutor
The Tutor is not available on this problem.

Example



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Practice Using Conjunction Elimination, Problem 1
1. (D & E) Prem
2. (F & G) Prem
3. F &EL 2
4. E &ER 1
5. (E & F) &I 4, 3
OPEN PROBLEM SET BROWSER
AProS
Problem Score: 1/1
Messages
Message 3 click here to open
Message 4 click here to open
Message 5 click here to open
YOU'VE COMPLETED THE PROBLEM!
You've completed the problem!
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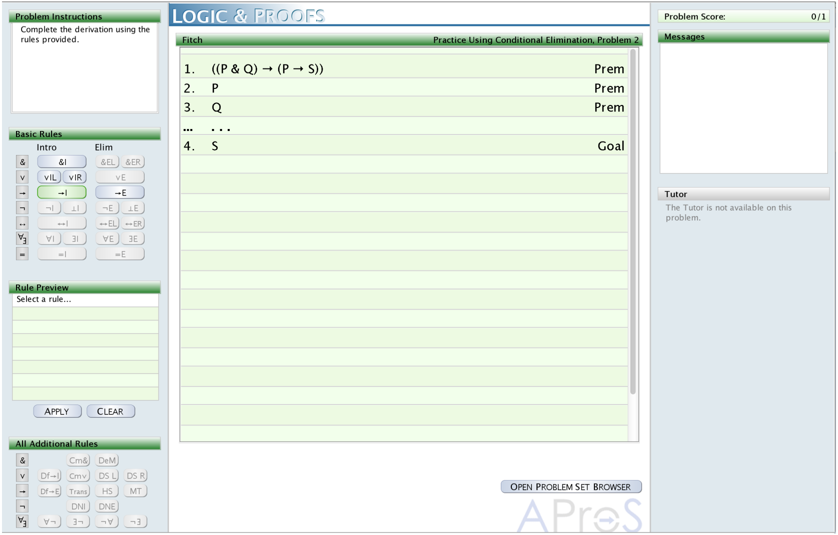
Conditional Elimination ($\rightarrow$ E)

$p1.$	φ	
$p2.$	$(\varphi \rightarrow \psi)$	
	$\vdots$	
c.	ψ	$\rightarrow$E : $p1$, $p2$

Example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Basic Rules
Intro
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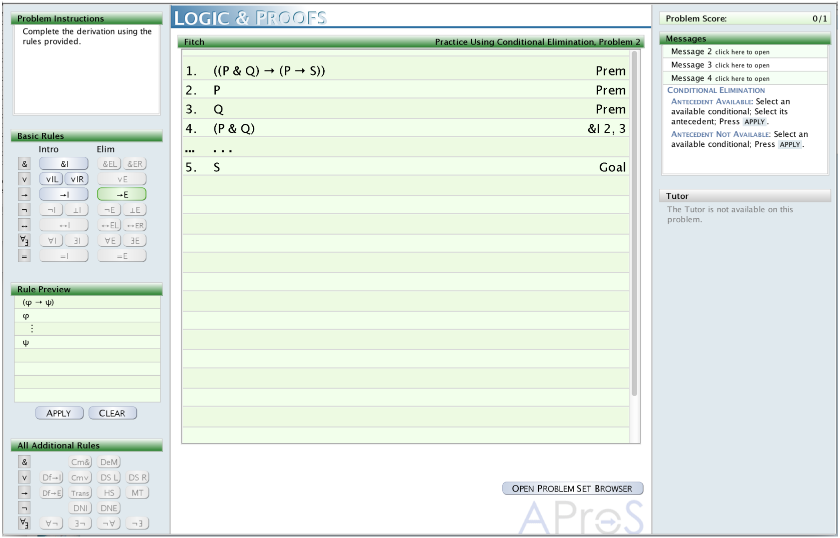
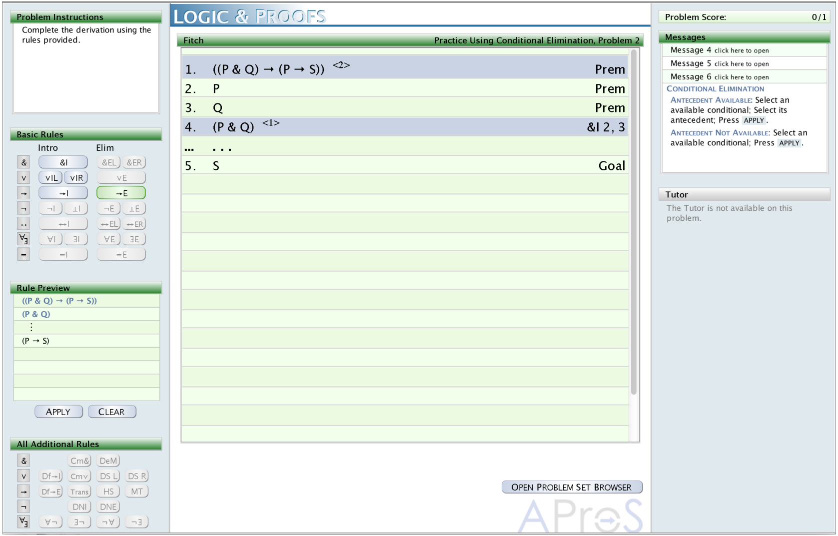
Select a rule...
APPLY
CLEAR
All Additional Rules
LOGIC & PROOFS
Fitch
Practice Using Conditional Elimination, Problem 2
1. ((P & Q) → (P → S)) Prem
2. P Prem
3. Q Prem
4. S Goal
OPEN PROBLEM SET BROWSER
APROS
Problem Score: 0/1
Messages
Tutor
The Tutor is not available on this problem.

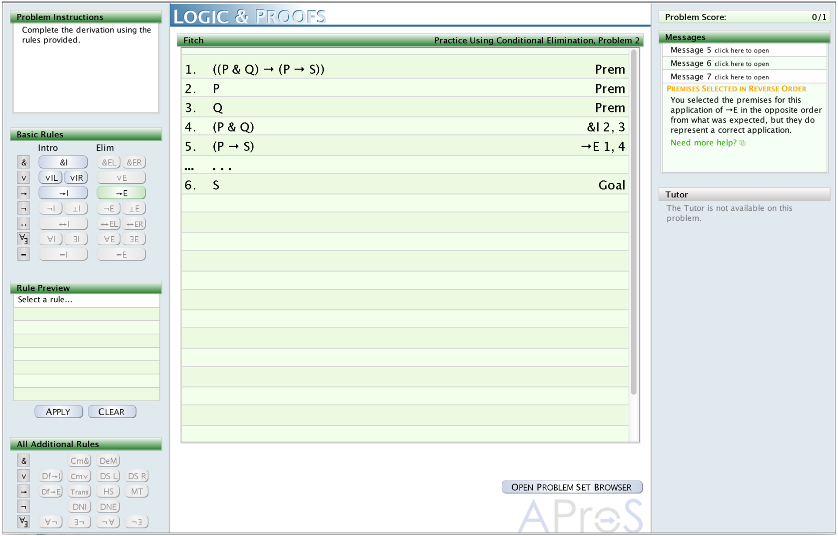
Example


Problem Instructions
Complete the derivation using the rules provided.
Basic Rules
Intro
Elim
&I
&EL &ER
∨IL ∨IR
∨E
→I
→E
¬I ⊥I
¬E ⊥E
↔I
↔EL ↔ER
∀I ∃I
∀E ∃E
=I
=E
Rule Preview
(φ → ψ)
φ
⋮
ψ
APPLY
CLEAR
All Additional Rules
Cm& DeM
Df→I Cm∨ DS L DS R
Df→E Trans HS MT
DNI DNE
∀¬ ∃¬ ¬∀ ¬∃
LOGIC & PROOFS
Fitch
Practice Using Conditional Elimination, Problem 2
1. ((P & Q) → (P → S)) Prem
2. P Prem
3. Q Prem
4. (P & Q) &I 2, 3
... . . .
5. S Goal
OPEN PROBLEM SET BROWSER
AProS
Problem Score: 0/1
Messages
Message 2 click here to open
Message 3 click here to open
Message 4 click here to open
CONDITIONAL ELIMINATION
ANTECEDENT AVAILABLE: Select an available conditional; Select its antecedent; Press APPLY.
ANTECEDENT NOT AVAILABLE: Select an available conditional; Press APPLY.
Tutor
The Tutor is not available on this problem.

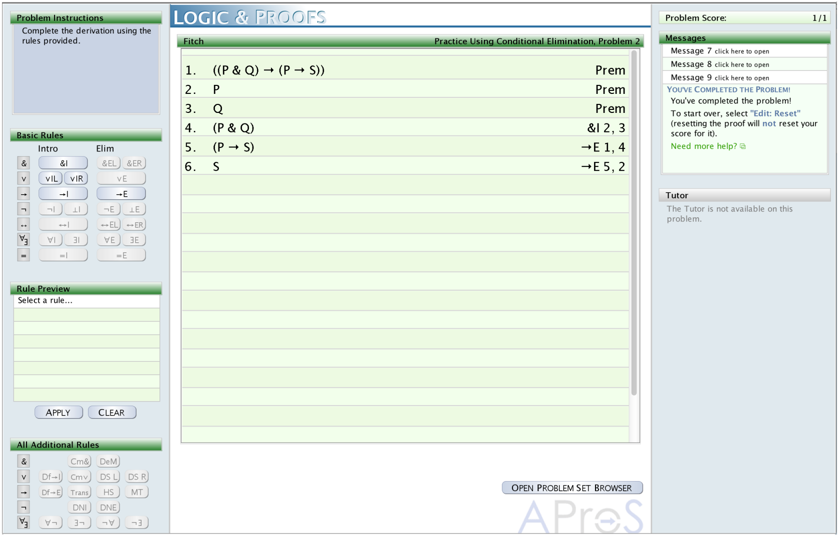
Example


Problem Instructions
Complete the derivation using the rules provided.
Basic Rules
Intro
Elim
Rule Preview
((P & Q) → (P → S))
(P & Q)
(P → S)
APPLY
CLEAR
All Additional Rules
LOGIC & PROOFS
Fitch
Practice Using Conditional Elimination, Problem 2
1. ((P & Q) → (P → S)) <2> Prem
2. P Prem
3. Q Prem
4. (P & Q) <1> &I 2, 3
5. S Goal
OPEN PROBLEM SET BROWSER
APROS
Problem Score: 0/1
Messages
Message 4 click here to open
Message 5 click here to open
Message 6 click here to open
CONDITIONAL ELIMINATION
ANTECEDENT AVAILABLE: Select an available conditional; Select its antecedent; Press APPLY.
ANTECEDENT NOT AVAILABLE: Select an available conditional; Press APPLY.
Tutor
The Tutor is not available on this problem.

Example


Problem Instructions
Complete the derivation using the rules provided.
Basic Rules
Intro
Elim
&I
&EL
&ER
∨IL
∨IR
∨E
→I
→E
¬I
⊥I
¬E
⊥E
↔I
↔EL
↔ER
∀I
∃I
∀E
∃E
=I
=E
Rule Preview
Select a rule...
APPLY
CLEAR
All Additional Rules
Cm&
DeM
Df→I
Cm∨
DS L
DS R
Df→E
Trans
HS
MT
DNI
DNE
∀¬
∃¬
¬∀
¬∃
LOGIC & PROOFS
Fitch
Practice Using Conditional Elimination, Problem 2
1. ((P & Q) → (P → S)) Prem
2. P Prem
3. Q Prem
4. (P & Q) &I 2, 3
5. (P → S) →E 1, 4
... . . .
6. S Goal
OPEN PROBLEM SET BROWSER
AProS
Problem Score: 0/1
Messages
Message 5 click here to open
Message 6 click here to open
Message 7 click here to open
PREMISES SELECTED IN REVERSE ORDER
You selected the premises for this application of →E in the opposite order from what was expected, but they do represent a correct application.
Need more help?
Tutor
The Tutor is not available on this problem.

Example


Problem Instructions
Complete the derivation using the rules provided.
Basic Rules
Intro
Elim
Rule Preview
Select a rule...
APPLY
CLEAR
All Additional Rules
LOGIC & PROOFS
Fitch
Practice Using Conditional Elimination, Problem 2
1. ((P & Q) → (P → S)) Prem
2. P Prem
3. Q Prem
4. (P & Q) &I 2, 3
5. (P → S) →E 1, 4
6. S →E 5, 2
OPEN PROBLEM SET BROWSER
Problem Score: 1/1
Messages
Message 7 click here to open
Message 8 click here to open
Message 9 click here to open
YOU'VE COMPLETED THE PROBLEM!
You've completed the problem!
To start over, select "Edit: Reset" (resetting the proof will not reset your score for it).
Need more help?
Tutor
The Tutor is not available on this problem.