Rational Analysis of Some Shots @ R

Selmer Bringsjord

Are Humans Rational?

9/12/16

Selmer.Bringsjord@gmail.com
Bit of Historical Context …
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2016

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elements of the branch of logic known as intensional operators for logics (e.g., FOL and SOL), to logics with intensional operators for of increasing expressivity that ranges from expressive extensional logical system to be positioned relative to three dimensions, which are undertaking within a view of logic that allows a particular action initially.

\[
\begin{array}{c}
\text{Fig. 1.} \\
\end{array}
\]

\[
DCEC^*
\]
Proof that if there is a body b whose
wordline for observer m passes through
point p but not through q or through b
but not through p, then the events
observed by m at p and q are different.

There is a point r reachable at the speed of light from p but
not from q for observer m.

m observes that there is a
body which passes through p
but not through q or through
q but not through p.
The elements of the branch of logic known as DCEC always position some particular work he and likeminded collaborators.

Proof that if there is a body b whose wordline for observer m passes through point p but not through q or through r but not through p, then the events observed by m at p and q are different.

There is a point r reachable at the speed of light from p but not from q for observer m.

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The theorem

Skeptic: If there is a body b whose wordline for observer m passes through point p but not through q or through r but not through p, then the events observed by m at p and q are different.

Skeptic: There is a point r reachable at the speed of light from p but not from q for observer m.

m observes that there is a body which passes through q but not through r or through q but not through p.

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elements of the branch of logic known as conditional logic. In the final production to the sub-field in formal logic of conditional logic. No matter what the underlying implementation of also has an associated knowledge-base can install. We view a robot abstractly as a third except that the logic in question includes aspects of conditional logic.
elements of the branch of logic known as...
Theorem: TTPoss
(deduced from GenRel)

DCEC

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DCEC

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The elements of the branch of logic known as conditional logic: as shown in Figure 1.

Figure 1.

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Moral/Ethical Stack

Syntax and Rules of Inference

Syntax and Rules of Inference
The final layer in our hierarchy is built upon an even more expressive logical system to be positioned relative to three dimensions, which always position some particular work he and likeminded collaborators first.

**Syntax and Rules of Inference**

- **Agent**: `Agent`
- **Event**: `Event`
- **Fluent**: `Fluent`
- **Boolean**: `Boolean`
- **ActionType**: `ActionType`
- **Moment**: `Moment`
- **D**: `D`
- **S**: `S`
- **K**: `K`
- **C**: `C`
- **T**: `T`
- **n**: `n`
- **f**: `f`
- **x**: `x`
- **h**: `h`
- **t**: `t`
- **i**: `i`
- **R**: `R`
- **O**: `O`
- **B**: `B`
- **I**: `I`
- **A**: `A`
- **DCEC**: `DCEC`
elements of the branch of logic known as first-class elements of the language for logics (e.g., FOL and SOL), to logics with intensional operators for DCEC:

\[ S :: \]

\[ = \]

\[ t \]

\[ \Rightarrow \]

\[ interval \]

\[ happens \]

\[ Boolean \]

\[ Fluent \]

\[ K \]

\[ | \]

\[ Event \]

\[ ActionType \]

\[ holds \]

\[ Fluent \]

\[ ^ \]

\[ Boolean \]

\[ | \]

\[ ! \]

\[ \Rightarrow \]

\[ interval \]

\[ initiates \]

\[ clipped \]

\[ initially \]

\[ Moment \]

\[ Object \]

\[ t \]

\[ \Rightarrow \]

\[ t \]

\[ (!) \]

\[ action \]

\[ t \]

\[ a \]

\[ B \]

\[ O \]

\[ x \]

\[ C \]

\[ self \]

\[ R \]

\[ KB \]

\[ ADR \]

\[ DCEC \]

\[ 1666 \]

\[ 2016 \]

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DCEC*
Leibniz 1666

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1.5 centuries < Boole

Leibniz

1666

2016

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1.5 centuries < Boole

Leibniz

1666

2016

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“Universal Computational Logic”

1666
Leibniz
1.5 centuries < Boole

2016
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DCEC*

Image
“Universal Computational Logic”

1666
Leibniz
1.5 centuries < Boole

1854

2016

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Leibniz (1666) and Boolean Algebra: The invention of Boolean algebra by George Boole in 1854 paved the way for modern logic and computer science. Alan Turing’s Logic Theorist, developed in 1956, was one of the first AI systems to prove mathematical theorems using logical reasoning. The end of the 20th century saw the rise of neural networks and statistical AI, which continue to be significant areas of research today. The timeline illustrates the evolution of computational logic from the conceptualization of Leibniz to the practical applications of modern AI.

**Fig. 3. Pictorial Overview of the Situation Now**

The timeline shows the progression from Leibniz to the development of modern AI systems. The first layer involves the foundation of Boolean logic, followed by the creation of the Logic Theorist in 1956. The final layer in the hierarchy is built upon even more expressive logics, highlighting the evolution of computational logic.

**Fig. 2.** The heirarchy of logics, showing their expressive power.

**Fig. 1.** The heirarchy of logics, showing their expressive power.

**Logic Theorist**

(birth of modern logicist AI)
(birth of agent-based/behavioral econ)

1666

1854

1956

2016

Leibniz

Simon

1.5 centuries < Boole
“Universal Computational Logic”

Logic Theorist
(birth of modern logicist AI)
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DCEC*

1666
Leibniz
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1956
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1666
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2020

The Future?
(rationally considered)

DCEC*
“Universal Computational Logic”

Logic Theorist (birth of modern logicist AI) (birth of agent-based/behavioral econ)

Leibniz
1.5 centuries < Boole

Simon

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The Future? (rationally considered)

1666

1854

1956

2016

2020

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“Universal Computational Logic”

Logic Theorist (birth of modern logicist AI)
(birth of agent-based/behavioral econ)

1666
Leibniz
1.5 centuries < Boole

1854

An Investigation of the Laws of Thought
George Boole

1956
Simon

2016
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The Future? (rationally considered)

Propositional Calculus!
First Elements of the Propositional Calculus
First Elements of the Propositional Calculus

Variables to represent declarative statements.
First Elements of the Propositional Calculus

Variables to represent declarative statements.

E.g., $k$ to represent ‘There is a king in the hand’.
First Elements of the Propositional Calculus

Variables to represent declarative statements.

E.g., $k$ to represent ‘There is a king in the hand’.

And five simple Boolean connectives:
First Elements of the Propositional Calculus

Variables to represent declarative statements.

E.g., \( k \) to represent ‘There is a king in the hand’.

And five simple Boolean connectives:

\[
\text{not } \neg \quad \text{and } \land \quad \text{or (inclusive) } \lor \quad \text{if ... then ... } \rightarrow \quad \text{... if and only if ... } \leftrightarrow
\]
Wason Selection Task

Suppose I claim that the following rule is true.

If a card has a vowel on one side, it has an even number on the other side.

Which card or cards should you turn over in order to try to decide whether the rule is true or false?
Suppose I claim that the following rule is true.

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Suppose I claim that the following rule is true.

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Which card or cards should you turn over in order to try to decide whether the rule is true or false?
Basic Picture

$<\vartheta, \pi> \rightarrow_{Li} \text{"proof"}$
Ok, so where’s the proof (or at least the compelling argument)?
Suppose I claim that the following rule is true.

If a card has a vowel on one side, it has an even number on the other side.

Which card or cards should you turn over in order to try to decide whether the rule is true or false?
Wason Selection Task

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Suppose I claim that the following rule is true:

If a card has a vowel on one side, it has an even number on the other side.

Which card or cards should you turn over in order to try to decide whether the rule is true or false?

Proposition: You should flip \( c_1 \)!

Proof: Were you to flip \( c_1 \), there are two and only two general cases that might appear before your eyes: you find an odd number; or else you find an even number. Well, if you find an odd number, you can stop, because the rule in question would then be refuted (since you have a case where the antecedent (vowel on one side) holds, but the consequent (even number on the other side) doesn’t. Since this might well happen for all you know, you should flip over \( c_1 \). QED
Proposition 2: You should flip c4!

Proof: Were you to flip c4, there are two and only two general cases that might appear before your eyes: you find a vowel; or else you find a consonant. Well, if you find a vowel, you can stop, because the rule in question would then be refuted (since you have a case where the antecedent (vowel on one side) holds, but the consequent (even number on the other side) doesn’t. Since this might well happen for all you know, you should flip over c4. QED
Given the statements

\( \neg a \lor \neg b \)
b
c \rightarrow a

which one of the following statements must also be true?

c
\( \neg b \)
\( \neg c \)
h
a
none of the above
Given the statements

\( \neg a \lor \neg b \)

\( b \)

\( c \rightarrow a \)

which one of the following statements must also be true?

\( c \)

\( \neg b \)

\( \neg c \)

h

a

one of the above
Proposition: The correct answer is ¬c.

Proof: We are given that b; that’s the second statement. Well, if b holds, then ¬b doesn’t hold. The first statement tells us that either ¬a or ¬b. So from this and the derived proposition that ¬b doesn’t hold we can infer ¬a. (If you know P or Q, and you know not-Q, you immediately know P; this inference rule is called disjunctive syllogism.) But from ¬a and c → a we can deduce that c can’t be the case; i.e., we can deduce ¬c. (This last inference is sanctioned by the rule of inference called modus tollens.) QED
Given the statements
\neg \neg c
\neg c \rightarrow a
\neg a \lor b
b \rightarrow d
\neg (d \lor e)

which one of the following statements must also be true?

\neg c
e
h
\neg a
all of the above
Given the statements
\neg \neg c \\
c \rightarrow a \\
\neg a \lor b \\
b \rightarrow d \\
\neg (d \lor e)

which one of the following statements must also be true?

\neg c \\
e \\
h \\
\neg a \\
all of the above
CSCI 2200: Foundations of Computer Science – Spring 2015

**General Information**
Instructor: Stacy Patterson  sep@cs.rpi.edu  518-276-2054

**Teaching Assistants**
- Ashwin Bahulkar  bahula@rpi.edu
- Lingxun Hu  hul5@rpi.edu
- Md. Ricwan Aliqbal  icibalm@rpi.edu
- Jai Wadhwani  wadhwja@rpi.edu

**Web site:**  http://www.cs.rpi.edu/~sep/csci2200


**Lectures:** MR 10:00am – 11:50 pm, Russell Sage Laboratory 3303

**Recitations:**
- Section 01  W 10:00am – 10:50am  Troy Building 2012
- Section 02  W 11:00am – 11:50am  Troy Building 2012
- Section 03  W 12:00pm – 12:50pm  Troy Building 2018
- Section 04  W 4:00pm – 4:50pm  Walker Laboratory 5113

**Course Description**
This course introduces important mathematical and theoretical tools for computer science, including topics from logic, number theory, set theory, combinatorics, and probability theory. The course then proceeds to automata theory, the Turing Machine model of computation, and notions of computational complexity. The course will emphasize formal reasoning and proof techniques.

Upon successful completion of this course, each student:
- is able to formulate mathematical proofs using logic
- is able to apply mathematical tools such as induction and recursion
- can recall key definitions from set theory
- is able to formulate combinatorial arguments
- is able to distinguish between various computational models
- is able to think critically on the difficulties of key questions in foundations of computer science
- can recall key facts regarding finite automata and Turing machines.

**Pre-requisites:** Intro to Calculus (MATH-1010 or MATH-1500); CSCI-1100 (CS I) or CSCI-1200 (Data Structures)

**Recitation**
Attendance at recitation is not required. Attendance will be taken at recitation, and students who attend regularly will get priority in office hours.

**Schedule**
An up-to-date schedule will be maintained on the course web site

**Homework**
There will be 9 homework assignments. The lowest homework grade will be dropped. Homework is due at the beginning of class on the date indicated on the homework assignment. You may turn in an assignment at the beginning of following class for a 50% penalty. No homework will be accepted after that time without a letter from the Student Experience office.
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  Md. Ricwan Al Iqbal  icbalm@rpi.edu
  Jai Wadhwan  wadhwa@rpi.edu
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### Table 1: Rules of Inference.

<table>
<thead>
<tr>
<th>Rule of Inference</th>
<th>Tautology</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>( p )</td>
<td>((p \land (p \rightarrow q)) \rightarrow q)</td>
<td>Modus ponens</td>
</tr>
<tr>
<td>( p \rightarrow q )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \therefore q)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \neg q )</td>
<td>((\neg q \land (p \rightarrow q)) \rightarrow \neg p)</td>
<td>Modus tollens</td>
</tr>
<tr>
<td>( p \rightarrow q )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \therefore \neg p)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( p \land q )</td>
<td>(((p \land q) \land (q \rightarrow r)) \rightarrow (p \rightarrow r))</td>
<td>Hypothetical syllogism</td>
</tr>
<tr>
<td>( q \rightarrow r)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \therefore p \rightarrow r)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( p \lor q )</td>
<td>(((p \lor q) \land \neg p) \rightarrow q)</td>
<td>Disjunctive syllogism</td>
</tr>
<tr>
<td>( \neg p )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \therefore q)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( p \lor q )</td>
<td>(((p \land q) \rightarrow (p \lor q))</td>
<td>Addition</td>
</tr>
<tr>
<td>( \therefore p \lor q)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( p \land q )</td>
<td>((p \land q) \rightarrow p)</td>
<td>Simplification</td>
</tr>
<tr>
<td>( \therefore p)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( p \land q )</td>
<td>(((p \land q) \rightarrow (p \land q))</td>
<td>Conjunction</td>
</tr>
<tr>
<td>( q )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \therefore p \lor q)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( p \lor q )</td>
<td>(((p \lor q) \land (\neg p \lor r)) \rightarrow (q \lor r))</td>
<td>Resolution</td>
</tr>
<tr>
<td>( \neg p \lor r)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \therefore q \lor r)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**EXAMPLE 3** State which rule of inference is the basis of the following argument: “It is below freezing. Therefore, it is either below freezing or raining now.”

**Solution:** Let \( p \) be the proposition “It is below freezing now,” and \( q \) the proposition “It is raining now.” Then this argument is of the form

\[ p \rightarrow (p \lor q) \]

\[ \therefore p \lor q \]

This is an argument that uses the addition rule.

**EXAMPLE 4** State which rule of inference is the basis of the following argument: “It is below freezing; raining now. Therefore, it is below freezing now.”

**Solution:** Let \( p \) be the proposition “It is below freezing now,” and let \( q \) be the proposition “It is raining now.” This argument is of the form

\[ (p \land q) \rightarrow (p \lor q) \]

\[ \therefore p \land q \]

This argument uses the simplification rule.
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| \( p \rightarrow q \)
| \( \therefore q \) | \((p \wedge (p \rightarrow q)) \rightarrow q\) | Modus ponens |
| \( \neg q \)
| \( p \rightarrow q \)
| \( \therefore \neg p \) | \((\neg q \wedge (p \rightarrow q)) \rightarrow \neg p\) | Modus tollens |
| \( p \rightarrow q \)
| \( q \rightarrow r \)
| \( \therefore p \rightarrow r \) | \(((p \rightarrow q) \wedge (q \rightarrow r)) \rightarrow (p \rightarrow r)\) | Hypothetical syllogism |
| \( p \lor q \)
| \( \neg q \)
| \( \therefore q \) | \(((p \lor q) \land \neg p) \rightarrow q\) | Disjunctive syllogism |
| \( p \)
| \( \therefore p \lor q \) | \(p \rightarrow (p \lor q)\) | Addition |
| \( p \land q \)
| \( \therefore p \) | \((p \land q) \rightarrow p\) | Simplification |
| \( p \)
| \( q \)
| \( \therefore p \land q \) | \(((p) \land (q)) \rightarrow (p \land q)\) | Conjunction |
| \( p \lor q \)
| \( \neg p \lor r \)
| \( \therefore q \lor r \) | \(((p \lor q) \land (\neg p \lor r)) \rightarrow (q \lor r)\) | Resolution |

**EXAMPLE 3** State which rule of inference is the basis of the following argument: “It is below freezing. Therefore, it is either below freezing or raining now.”

**Solution:** Let \( p \) be the proposition “It is below freezing now” and \( q \) the proposition “It is raining now.” The rule of inference is **Addition**.
### Table 1: Rules of Inference

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<td>Hypothetical syllogism</td>
</tr>
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</tr>
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<td>Simplification</td>
</tr>
<tr>
<td>( p \rightarrow q )</td>
<td>( q \lor \neg p ) ( p \lor q ) ( ((p \land \neg q) \rightarrow (q \lor r) )</td>
<td>Conjunction</td>
</tr>
<tr>
<td>( p \lor q )</td>
<td>( \neg p \lor r ) ( (p \lor q) \land \neg p \rightarrow (q \lor r) )</td>
<td>Resolution</td>
</tr>
</tbody>
</table>

### Example 3
State which rule of inference is the basis of the following argument: “It is below freezing. Therefore, it is either below freezing or raining now.”

**Solution:** Let \( p \) be the proposition “It is below freezing now” and \( q \) the proposition “It is raining.” The rule of inference is the first row of the table.
Explosion Rule!
Explosion Rule!

\[ p \land \neg p \]

\[ \quad \quad \quad \quad q \]
Explosion Rule!

\[ p \land \neg p \]

\[ \underline{\quad} \]

\[ q \]

Easy peasy to prove in Rosen:
Explosion Rule!

\[ p \land \neg p \]

\[ \quad q \]

Easy peasy to prove in Rosen:

(1) \( p \land \neg p \)  Premise
(2) \( p \)  Simplification using (1)
(3) \( p \lor q \)  Addition using (2)
(4) \( \neg p \)  Simplification using (1)
(5) \( q \)  Disjunctive Syllogism using (3) and (4)
EXAMPLE 6

Show that the premises “It is not sunny this afternoon and it is colder than yesterday,” “We will go swimming only if it is sunny,” “If we do not go swimming, then we will take a canoe trip,” and “If we take a canoe trip, then we will be home by sunset” lead to the conclusion “We will be home by sunset.”

**Solution:** Let $p$ be the proposition “It is sunny this afternoon,” $q$ the proposition “It is colder than yesterday,” $r$ the proposition “We will go swimming,” $s$ the proposition “We will take a canoe trip,” and $t$ the proposition “We will be home by sunset.” Then the premises become $\neg p \land q$, $r \rightarrow p$, $\neg r \rightarrow s$, and $s \rightarrow t$. The conclusion is simply $t$. We need to give a valid argument with premises $\neg p \land q$, $r \rightarrow p$, $\neg r \rightarrow s$, and $s \rightarrow t$ and conclusion $t$.

We construct an argument to show that our premises lead to the desired conclusion as follows:

<table>
<thead>
<tr>
<th>Step</th>
<th>Reason</th>
</tr>
</thead>
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<tr>
<td>1. $\neg p \land q$</td>
<td>Premise</td>
</tr>
<tr>
<td>2. $\neg p$</td>
<td>Simplification using (1)</td>
</tr>
<tr>
<td>3. $r \rightarrow p$</td>
<td>Premise</td>
</tr>
<tr>
<td>4. $\neg r$</td>
<td>Modus tollens using (2) and (3)</td>
</tr>
<tr>
<td>5. $\neg r \rightarrow s$</td>
<td>Premise</td>
</tr>
<tr>
<td>6. $s$</td>
<td>Modus ponens using (4) and (5)</td>
</tr>
<tr>
<td>7. $s \rightarrow t$</td>
<td>Premise</td>
</tr>
<tr>
<td>8. $t$</td>
<td>Modus ponens using (6) and (7)</td>
</tr>
</tbody>
</table>

Note that we could have used a truth table to show that whenever each of the four hypotheses is true, the conclusion is also true. However, because we are working with five propositional variables, $p$, $q$, $r$, $s$, and $t$, such a truth table would have 32 rows.
Given the statements
\(\neg\neg c\)
\(c \rightarrow a\)
\(\neg a \lor b\)
\(b \rightarrow d\)
\(\neg (d \lor e)\)

which one of the following statements must also be true?

\(\neg c\)
\(e\)
\(h\)
\(\neg a\)
all of the above
Given the statements
¬¬c

¬a ∨ b

b → d

¬(d ∨ e)

which one of the following statements must also be true?

¬c
e
h
¬a
all of the above
Given the statements
¬¬c
\(c \rightarrow a\)
\(\neg a \lor b\)
\(b \rightarrow d\)

\(\neg (d \lor e)\)

which one of the following statements must also be true?

¬c
e
h
¬a
all of the above
Given the statements
\neg \neg c \implies c
\neg a \lor b
b \implies d
d \lor e
\neg (d \lor e)

which one of the following statements must also be true?

\neg c

e

h

\neg a

all of the above
Given the statements
\[ \neg\neg c \rightarrow c \]
\[ c \rightarrow a \]
\[ \neg a \vee b \]
\[ b \rightarrow d \]
\[ \neg(d \vee e) \]

which one of the following statements must also be true?

\[ \neg c \]
\[ e \]
\[ h \]
\[ \neg a \]
\[ all \ of \ the \ above \]
Given the statements

\[ \neg \neg c \rightarrow c \]
\[ c \rightarrow a \]
\[ \neg a \lor b \]
\[ b \rightarrow d \]
\[ \neg (d \lor e) \rightarrow \neg d \land \neg e \]

which one of the following statements must also be true?

\[ \neg c \]
\[ e \]
\[ h \]
\[ \neg a \]

all of the above
Given the statements

\[ \neg c \]
\[ c \rightarrow a \]
\[ \neg a \lor b \]
\[ b \rightarrow d \]
\[ \neg (d \lor e) \]

which one of the following statements must also be true?

\[ \neg c \]
\[ e \]
\[ h \]
\[ \neg a \]
\[ \text{all of the above} \]

Homework 1: Prove that the answer to this problem is indeed “all of the above,” using tools provided to you in the present slide deck.
Which one of the following statements is logically equivalent to the following statement: “If you are not part of the solution, then you are part of the problem.”

If you are part of the solution, then you are not part of the problem.

If you are not part of the problem, then you are part of the solution.

If you are part of the problem, then you are not part of the solution.

If you are not part of the problem, then you are not part of the solution.
“NYS 2”

Which one of the following statements is logically equivalent to the following statement: “If you are not part of the solution, then you are part of the problem.”

If you are part of the solution, then you are not part of the problem.

If you are not part of the problem, then you are part of the solution.

If you are part of the problem, then you are not part of the solution.

If you are not part of the problem, then you are not part of the solution.
Which one of the following statements is logically equivalent to the following statement: “If you are not part of the solution, then you are part of the problem.”

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If you are part of the problem, then you are not part of the solution.

If you are not part of the problem, then you are not part of the solution.
More-Recent Shots …
The Original King-Ace

Suppose that the following premise is true:

If there is a king in the hand, then there is an ace in the hand, or else if there isn’t a king in the hand, then there is an ace.

What can you infer from this premise?
The Original King-Ace

Suppose that the following premise is true:

If there is a king in the hand, then there is an ace in the hand, or else if there isn’t a king in the hand, then there is an ace.

What can you infer from this premise?

There is an ace in the hand.
The Original King-Ace

Suppose that the following premise is true:

If there is a king in the hand, then there is an ace in the hand, or else if there isn’t a king in the hand, then there is an ace.

What can you infer from this premise?

There is an ace in the hand.
The Original King-Ace

Suppose that the following premise is true:

If there is a king in the hand, then there is an ace in the hand, or else if there isn’t a king in the hand, then there is an ace.

What can you infer from this premise?

NO! There is an ace in the hand.
The Original King-Ace

Suppose that the following premise is true:

If there is a king in the hand, then there is an ace in the hand, or else if there isn’t a king in the hand, then there is an ace.

What can you infer from this premise?

NO! There is an ace in the hand. NO!
The Original King-Ace

Suppose that the following premise is true:

If there is a king in the hand, then there is an ace in the hand, or else if there isn’t a king in the hand, then there is an ace.

What can you infer from this premise?

NO! There is an ace in the hand. NO!

In fact, what you can infer is that there isn’t an ace in the hand!
Suppose that the following premise is true:

*If there is a king in the hand, then there is an ace in the hand; or if there isn’t a king in the hand, then there is an ace; but not both of these if-then statements are true.*

What can you infer from this premise?
King-Ace 2

Suppose that the following premise is true:

If there is a king in the hand, then there is an ace in the hand; or if there isn’t a king in the hand, then there is an ace; but not both of these if-then statements are true.

What can you infer from this premise?

There is an ace in the hand.
Suppose that the following premise is true:

*If there is a king in the hand, then there is an ace in the hand; or if there isn’t a king in the hand, then there is an ace; but not both of these if-then statements are true.*

What can you infer from this premise?

*There is an ace in the hand.*
Suppose that the following premise is true:

If there is a king in the hand, then there is an ace in the hand; or if there isn’t a king in the hand, then there is an ace; but not both of these if-then statements are true.

What can you infer from this premise?

NO! There is an ace in the hand.
Suppose that the following premise is true:

If there is a king in the hand, then there is an ace in the hand; or if there isn’t a king in the hand, then there is an ace; but not both of these if-then statements are true.

What can you infer from this premise?

NO! There is an ace in the hand. NO!
Suppose that the following premise is true:

*If there is a king in the hand, then there is an ace in the hand; or if there isn’t a king in the hand, then there is an ace; but not both of these if-then statements are true.*

What can you infer from this premise?

**NO!** There is an ace in the hand.** NO!**

In fact, what you *can* infer is that there *isn’t* an ace in the hand!
King-Ace Solved

**Proposition:** There is *not* an ace in the hand.

**Proof:** We know that at least one of the if-thens (i.e., at least one of the conditionals) is false. We know this because we are told that either the first if-then holds, or the second if-then holds, but not both.

So we have two cases to consider, viz., that $K \rightarrow A$ is false, and (the other case) that $\neg K \rightarrow A$ is false. ($\rightarrow$ is the same as the arrow we have used.)

Take first the first case; accordingly, suppose that $K \rightarrow A$ is false. Then it follows that $K$ is true (since, when a conditional is false, its antecedent holds but its consequent doesn’t), and $A$ is false; i.e., $\neg A$.

Now consider the second case, which consists in $\neg K \rightarrow A$ being false. Here, in a direct parallel, we know $\neg K$ and, once again, since the consequent of the conditional must be false, $\neg A$.

In both of our two cases, which are exhaustive, there is no ace in the hand. The proposition is established. **QED**
Proposition: There is not an ace in the hand.

Proof: We know that at least one of the if-thens (i.e., at least one of the conditionals) is false. We know this because we are told that either the first if-then holds, or the second if-then holds, but not both.

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