

Recent advances in refutations and validations using Meth8 modal logic model checker

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In applied and theoretical mathematics, assertions are categorized in alphabetical order as: axiom; conjecture; definition, entry; equation; expression; formula; functor; hypothesis; inequality; metatheorem; paradox; problem; proof; schema; system; theorem; and thesis. We evaluate 199 artifacts in 1030 assertions to confirm 231 as tautology and 799 as not (78%). We use Meth8, a modal logic checker in five models.

The semantic content or predicate basis of some expressions on their face does not disqualify them from evaluation by Meth8 in classical modal logic. However, the rules of classical logic, as based on the corrected Square of Opposition by Meth8, apply to virtually any logic system. Consequently some numerical equations are mapped to classical logic as Meth8 scripts.

The rationale for mapping quantifiers as modal operators is in the Appendix based on satisfiability and reproducibility of validation of syllogisms.

A table lists what was tested with separated results. The names are numbered in alphabetical order. Test results are Invalidated as Not Validated Tautology (nvt), *not* tautologous, or Validated as Tautology (vt), tautologous. For a paradox, *not* tautologous means it is not a paradox or contradiction.

The experimental tests used variables for 4 propositions, 4 theorems, and 11 propositions. The size of truth tables are respectively for 16-, 256-, and 2048- truth values. One formula of Popper in 250-characters processed in 125-steps instantly due to recent advances in look up table indexing.

The Meth8 modal theorem prover implements the logic system variant VL4 which corrects the quaternary Ł4 of Łukasiewicz. There are two sets of truth values on the 2-tuple {00, 10, 01, 11} as respectively {False proof for contradiction; Contingent for falsity; Non contingent for truthity; Tautology for proof} and {Unevaluated; Improper; Proper; Evaluated}. The designated proof value is T for tautology and E for evaluated. The model checker contains recent advances in parsing technology and is U.S. Patent Pending.

The mapping of formulas into Meth8 script was performed by hand, checked, and tested for accuracy of intent. (A semi-automation of that process is underway.) The Meth8 script uses literals and connectives in one-character. Propositions are p-z, and theorems are A-B. The connectives for {and, or, imply, equivalent} are {&, +, >, =}. The negated connectives for {nand; nor; not imply; exclusive-or} are {\, -, <, @}. The operators for {not; possibility $\diamond \exists$; necessity $\square \forall$ } are {\~, %, #}. Some expressions are adopted for clarity such as: (p=p) for tautologous; (p@p) for contradiction; and (x<y) for $x \in y$. The expression $x \leq y$ as "x less than or equal to y" is rendered in the negative as $\sim(y < x)$ or as $(\sim x > \sim y)$.

Definition	Axiom	Symbol	Name	Meaning	2-tuple	Binary ordinal
1	p=p	T	tautology	proof	11	3
2	p@p	F	contradiction	absurdum	00	0
3	%p>#p	N	non-contingency	truthity	01	1
4	%p<#p	C	contingency	falsity	10	2

Note the meaning of (%p>#p): a possibility of p implies the necessity of p; and some p implies all p. In other words, if a possibility of p then the necessity of p; and if some p then all p. This shows equivalence of respective modal operators and quantified operators, as proved in Appendix.

For Meth8 an immediate further application to "validate as tautologous" is mapping sentences of natural language into logical formulas. The approach identifies parts of speech as nouns, verbs, and modifiers. These translate into logical symbols for literals, connectives, and operators. For example: the conjunction "and" becomes the connective "&"; and the modifier articles "the" and "a" become the modal box # and lozenge %. Expressions for consecutive sentences are linked by the imply connective to build paragraphs to form requirements documents.

No.	Name of object	Type of object	Results with instances
1	ABC	Conjecture	Invalidated
2	Abductive reasoning	System	Invalidated
3	Alcoholics Anonymous BB: We agnostics, p 53	Traditions	Invalidated
4	Alexandroff correspondence	Conditional	Invalidated (3)
5	Anderson division by zero as nullity	Theorem	Invalidated
6	Axiomatizing category theory in free logic	Axioms	Invalidated
7	Banach-Tarski	Paradox	Invalidated
8	Barcan	Formula	Validated
9	Bayes rule	Rule	Invalidated (11) Validated(11)
10	BCI / BCK algebra	System	Invalidated (5) Validated (3)
11	Bell / CHSH / Spekken toy model	Inequalities	Invalidated
12	Simplest refutation	Theorem	Invalidated (2)
13	Berkeley	Paradox	Invalidated
14	Bernstein-Vazirani	Algorithm	Invalidated (4) Validated (1)
15	Bertrand-Chebyshev theorem / postulate	Theorem	Invalidated (2)
16	Biscuit conditionals	System	Invalidated (13)
17	Bogdanov map, 2D conjugate of Hénon map	Formula	Invalidated
18	Borsuk-Ulam (BUT)	Theorem	Validated
19	BUT extensible and non-invertive	Theorem	Validated (2)
20	BUT not needed on for 3D umbilic torus	Model	Invalidated(242)Validated(14)
21	Branching quantifier (Hintikka)	System	Invalidated
22	Buridan's Ass	Paradox	Invalidated
23	Cantor's continuum conjecture	Hypothesis	Invalidated (2)
24	Cantor's diagonal argument	Proof	Invalidated (3)
25	Cantor pairing	Functor	Invalidated (2)
26	Category composition of morphisms	Definition	Invalidated (1)
27	Chaitin incompleteness and L constant	Theorem	Invalidated (3) Validated (1)
87	Chinese room argument: Brain Simulator Reply	Conjecture	Validated (3)
29	Church	Thesis	Invalidated

30	Clausius-Clapeyron on spacial dimension	Equation	Invalidated (1)
31	Clifford tori 2D / Kanban cell neuron	Definition	Validated
32	(Lothar) Collatz	Conjecture	Validated
33	Complex (C), imaginary number rendering	Method	Invalidated (4) Validated (4)
34	Constructivistic logic	System	Invalidated (14) Validated (2)
35	Creative theories in degrees of unsolvability	Theorem	Invalidated
36	D Ultrafilter contra continuum problem	Equation	Invalidated (1)
37	Dedekind lattice identity	Axiom	Validated
38	Density of all Turing and truth table degrees	Formula	Invalidated (2)
39	Description logic	System	Invalidated (2)
40	Dialetheism	System	Invalidated (4)
41	Dialetheism: inconsistent	System	Invalidated (2)
42	Dichotomy of selection	System	Invalidated
43	Diverse double compiling	Schema	Invalidated
44	Doxastic logic	System	Invalidated (8) Validated (13)
45	$E=mc^2$	Theorem	Invalidated (3) Validated (1)
46	EF-axiom: topology and near sets	Axiom	Invalidated
47	Ehrenfeucht-Mostowski indiscernables	Theorem	Invalidated (1)
48	Energy-mass equation, $E=mc^2$	Theorem	Invalidated (3) Validated (1)
49	Epicurus invoked by Epictetus	Paradox	Invalidated (1)
50	Epistemic coalition	Perfect recall	Invalidated (4) Validated (3)
51	Epistemic dynamic reasoning	System	Invalidated (2)
52	Epistemic Hilbert substructure	System	Invalidated (5)
53	Epistemic navigation	System	Invalidated (8)
54	Epistemic quantifiers over agents	Conjecture	Invalidated (8) Validated (12)
55	Erdős-Strauss	Conjecture	Invalidated
56	Euathlus paradox	Paradox	Invalidated (9)
57	FOL disjunctive normal forms (DNF): minimize	FOL Optimizer	Invalidated (2) Validated (1)
58	Frequency dependence of mass	Theorem	Invalidated (3) Validated (1)
59	Functions as injective, surjective, bijective	Theorems	Validated (4)
60	Gentzen proof of sequent System G-M	System	Invalidated (6) Validated (2)
61	Gettier (Justified tautologous belief)	Conjecture	Validated
62	GHZ (Greenberger-Horne-Zeilinger)	Experiments	Invalidated (1)
63	Gödel compactness	Theorem	Invalidated (6) Validated (2)
64	Gödel completeness	Theorem	Invalidated

65	Gödel first incompleteness	Theorem	Invalidated (4)
66	Gödel incompleteness	Equations	Invalidated (14) Validated (1)
67	Gödel incompleteness FOL	Contradictions	Invalidated (14) Validated (1)
68	Gödel incompleteness theorem	Assistant tools	Invalidated (2) Validated (2)
69	Gödel incompleteness theorem	Refutation	Invalidated (7)
70	Gödel-Löb	Axiom	Invalidated
71	Gödel pairing function	Axiom	Invalidated (3) Validated (1)
72	Gödel recursion	Theorem	Validated
73	Gödel-Scott on God	Theorem schema	Invalidated
74	Goldbach's conjectures	Conjectures	Invalidated
75	Grassmannian (<i>recently discovered</i>)	Paradox	Invalidated
76	Hall	Effect	Invalidated
77	Hamiltonian quaternion	Definition	Invalidated (3)
78	Heisenberg uncertainty principle	Axiom	Invalidated (2)
79	Henkin cyclic algebra and first order logic	System	Invalidated (9) Validated (6)
80	Applications to logic	Axioms	Invalidated (8) Validated (6)
81	Permutation model nonrepresentable	Assertion	Invalidated (1)
82	Herbrand semantics	System	Invalidated (6)
83	Heyting-Brouwer intuitionistic logic	Systems	Invalidated (9) Validated (1)
84	Higher order logic	Systems	Invalidated (2) Validated (1)
85	Hilbert #10 Diophantine universal solution	Formulas	Invalidated
86	Hilbert generalization	System	Invalidated
87	Huhn 2-distributive lattice identity	Formula	Invalidated
88	Ignorance of first choice	System	Invalidated
89	Imaginary numbers	Definition	Invalidated (2)
90	Imperative logic	System	Invalidated (3) Validated (4)
91	Inconsistent theory	Theorem	Invalidated
92	Extending the monad to a triad	Formulas	Invalidated
93	Kunen inconsistency	Theorem	Invalidated
94	Independence-friendly logic (Kreiselization)	System	Invalidated (2)
95	Indicative conditionals	Encyclopedia entry	Invalidated
96	Induction: Black raven (swan); Kripkenstein	System	Invalidated (3)
97	Inequality: 'arbitrarily' vs 'sufficiently large'	Conjecture	Invalidated (2) Validated (1)
98	Infinite set theory	Theorem	Invalidated
99	Join-prime in lattice theory	Definition	Validated

100	Jonsson positive logic: retromorphism	System	Invalidated (3)
101	Kant: falsity of syllogistic figures	Theorems	Invalidated (8) Validated (2)
102	Karpenko, S.A.	System K-Ł4	Invalidated
103	Kramers-Kronig	Relation	Invalidated
104	Kuratowski–Zorn lemma (Zorn's lemma)	Lemma	Invalidated
105	Lachlan problem solution	Problem	Invalidated (4)
106	Leibniz' ontological proof	Proof	Invalidated (1) Validated (1)
107	Briefest known ontological proof of God	Proof	Validated (2)
108	Lemmon D	Axiom	Invalidated
109	Liar	Paradox	Invalidated
110	Prior rendition	Paradox	Invalidated
111	Kripke rendition	Paradox	Invalidated
112	Liouville	Theorem	Invalidated (2) Validated (1)
113	Löb original, corrected	Theorem	Invalidated (1) Validated (1)
114	Löwenheim–Skolem, Hilbert style	Metatheorem	Invalidated
115	Luce model (general)	Definitions/Axioms	Validated (5)
116	Majorana's 'root'	Equations	Invalidated (5)
117	Meth8 versus Prover9 via Lifshitz	Problem	Validated
118	Minkowski plane, classical set of points/cycles	Theorems	Invalidated (2) Validated (1)
119	Modified divine command	Theory	Invalidated
120	Necessitation: K,T,4,B,D,5 ; <i>D,M,S4,B,S5</i>	Axiom	Invalidated (10) Validated (7)
121	Leonard Nelson's criticism of epistemology	System	Invalidated
122	von Neuman-Bernays–Gödel [NBG]	Theory	Invalidated (2) Validated (3)
123	Neutrosophic logic	Theorems	Invalidated (5)
124	Dezert-Smarandache	Theory	Invalidated (2)
125	Generalized intuitionistic, fuzzy logic	System	Invalidated (2)
126	Neutrosophic sets	Properties	Invalidated (3)
127	Soft lattice theory	Theorem	Invalidated (2)
128	Unification of other logics	Axioms / Rules	Invalidated (2)
129	Values as 1, 0, between 0 and 1	Designated logic	Invalidated (2)
130	Vector space on $\{-0, 0, 0 < p < 1, 1, 1+\}$	Multi-valued logic	Invalidated (3)
131	Nucleosynthesis	Definitions	Invalidated (4)
132	P=NP; 3-SAT	Conjectures	Invalidated (5)
133	Paraconsistency, machine-assisted view	Axioms	Invalidated
134	Paraconsistent contradiction	Conext	Invalidated

135	Pauli exclusion	Principle	Validated
136	Peano arithmetic 9, 1-8	Axioms	Invalidated (1) Validated (8)
137	Poincaré recurrence theorem	Theorem	Invalidated (2)
138	Prenex normal format	Rules	Invalidated (11) Validated (3)
139	Karl Popper on God	Proof	Validated
140	PowerEpsilon mathematical induction	Axiom	Validated (1)
141	Prover9 vs Meth8 differences	System	Invalidated
142	Quantum control by observation	System	Invalidated
143	Quantum gates correspond to logical operators	Theorems	Invalidated (4) Validated (1)
144	Quantum simulation of Hamiltonian spectra	Operator	Invalidated (1)
145	Ramsey's theorem for the 2-color case	Theorem	Validated (2)
146	Ranjan, A.	Problem	Validated
147	Realizability semantics for QML	Theorems	Invalidated (3)
148	Reichenbach common cause / event-splitting	Principle	Invalidated
149	Riemann: only zeroes at 0, 1/2	Hypothesis	Invalidated
150	Zeta function, Caceres 6	Proposition	Invalidated (4)
151	Roman Catholic Church (RCC)	(Dogma)	Invalidated (7)
152	Erasmus contra Luther	Controversy	Validated
153	Infallibility and the Historic Church	Pius IX	Invalidated (2)
154	Magisterium	Paul VI	Invalidated (1)
155	Tradition above scripture	Pius IX	Invalidated (4)
156	Rota lattice theory, distributive	Axiom	Invalidated
157	Russell	Paradox	Invalidated
158	S5II+ propositional quantification	System	Invalidated
159	Schrödinger's cat	Paradox	Invalidated
160	Self-equilibrium	Law / Paradox	Invalidated
161	Sorites	Paradox	Invalidated
162	Special theory of relativity: Crothers refutation	Confirmation	Validated
163	Square of Opposition Meth8 Corrected	System	Validated
164	Square of Opposition Modern Revised	System	Invalidated
165	Square of Opposition	Proportions	Invalidated (3)
166	Stone space type lattice logic model	Theory	Invalidated (2)
167	Stone-Wales rotation transform reversibility	Theorem	Invalidated (2) Validated (1)
168	Superposition of states	Principle	Invalidated (6)
169	Tarski's undefinability of truth	Theorem	Invalidated (2)

170	Tarski–Grothendieck set theory	Axiom	Invalidated (2)
171	Tarski–Grothendieck Metamath ax-garth	Axiom	Invalidated (1)
172	Time as God	Conjecture	Validated (2)
173	Time as coexisting past, present, future states	Conjecture	Invalidated (3)
174	Topological manifold transition	Function	Invalidated (1)
175	Turing halting problem	Problem	Invalidated (2) Validated (1)
176	Twin paradox	Paradox	Invalidated (2)
177	Universal finite set	Theorem	Invalidated (2)
178	Veblen (corrected)	Axiom	Invalidated (1) Validated (1)
179	Veronoï regions (with "nonempty sets")	Definition	Invalidated
180	W (K4W)	Theorem	Invalidated
181	Well ordering property	Axiom	Invalidated
182	Wittgenstein's ab-notation	System	Invalidated (3)
183	Yalcin logic	Axioms	Invalidated (2)
184	Zadeh first operators on fuzzy logic	System	Invalidated (5)
185	Zermello-Fraenkel (ZFC):	(Axioms)	Invalidated (13) Validated (2)
186	ZFC Choice	Axiom	Invalidated
187	ZFC Empty set	Axiom	Invalidated
188	ZFC Extensionality	Axiom	Invalidated (1) Validated (1)
189	ZFC Infinity	Axiom	Invalidated (2)
190	ZF INF	Axiom	Invalidated
191	ZFC Pairing	Axiom	Invalidated
192	ZFC Power set	Axiom	Invalidated
193	ZFC Regularity or foundation	Axiom	Invalidated
194	ZFC Schema of replacement	Axiom	Invalidated
195	ZFC Specification	Axiom	Validated
196	ZFC Union	Axiom	Invalidated
197	ZFC Well ordering	Axiom	Invalidated (2)
198	ZF Law of excluded middle: infinite set	Axiom	Invalidated (2)
199	Zero and one in fractions	Axioms	Invalidated (3) Validated (8)
200	Zero knowledge proof	Theorem	Invalidated
201	Zeroth law of thermodynamics	Theorem	Invalidated (3) Validated (2)

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