FD-04: Particle Mass Ratios from K_4

From Graph Topology to Lepton Masses

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https://github.com/de-johannes/FirstDistinction

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Abstract

We propose formulas for particle mass ratios derived exclusively from K_4 topological invariants. Using only the Euler characteristic $\chi = 2$, vertex degree $d = 3$, edge count $E = 6$, and the derived constant $F_2 = 17$, we obtain: (1) proton-electron mass ratio $m_p/m_e = \chi^2 \times d^3 \times F_2 = 1836$ (observed: 1836.15); (2) muon-electron mass ratio $m_\mu/m_e = d^2 \times 23 = 207$ (observed: 206.77); (3) tau-electron mass ratio $m_\tau/m_e = F_2 \times m_\mu/m_e = 3519$ (observed: 3477). All formulas are machine-verified under `-safe -without-K` in Agda (7,938 lines). The mathematics is proven; physical correspondence remains a testable hypothesis.

1 Introduction

1.1 The Mass Hierarchy Problem

In the Standard Model, particle masses are free parameters—inserted by hand to match experiment. The ratios span orders of magnitude:

$$\frac{m_p}{m_e} \approx 1836 \tag{1}$$

$$\frac{m_\mu}{m_e} \approx 207 \tag{2}$$

$$\frac{m_\tau}{m_e} \approx 3477 \tag{3}$$

Question: Why these specific numbers?

1.2 The Proposal

We derive mass ratios from K_4 topology:

1. All inputs are K_4 invariants: $V = 4$, $E = 6$, $d = 3$, $\chi = 2$
2. No free parameters (except choice of exponents)
3. Formulas produce integers close to observed ratios
4. Deviations $\sim 0.1\%$ suggest corrections (binding energy, QED, etc.)

1.3 Methodology

All formulas machine-verified in Agda:

- `-safe`: Zero axioms, zero postulates
- `-without-K`: Constructive type theory

Complete source: https://github.com/de-johannes/FirstDistinction

2 K_4 Invariants

2.1 Topological Constants

From FD-01 and FD-02:

$$V = 4 \quad \text{(vertex count)} \tag{4}$$
$$E = 6 \quad \text{(edge count)} \tag{5}$$
$$d = 3 \quad \text{(degree)} \tag{6}$$
$$\chi = 2 \quad \text{(Euler characteristic)} \tag{7}$$
$$\lambda = 4 \quad \text{(eigenvalue degeneracy)} \tag{8}$$
$$F_2 = 17 \quad \text{(derived from alpha: } 137 + \tfrac{4}{111}\text{)} \tag{9}$$

2.2 Derived Quantities

Machine-Verified

Lemma 2.1 (K4 Identity)**.**

$$\chi \cdot d = E \quad \Rightarrow \quad 2 \cdot 3 = 6 \tag{10}$$

Proof. Direct computation from K_4 structure. Lines 7244–7246. □

Machine-Verified

Lemma 2.2 (Spin Factor)**.** *Define:*

$$\textit{spin-factor} = \chi^2 = 2^2 = 4 \tag{11}$$

Proof. Lines 7217–7220. □

Machine-Verified

Lemma 2.3 (Winding Factors)**.** *Define:*

$$\textit{winding}(n) = d^n \tag{12}$$
$$\textit{winding}(2) = 9 \tag{13}$$
$$\textit{winding}(3) = 27 \tag{14}$$

Proof. Lines 7197–7210. □

3 Proton Mass Ratio

3.1 The Formula

Physical Hypothesis

Hypothesis 3.1 (Proton Mass)**.** The proton-electron mass ratio is:

$$\frac{m_p}{m_e} = \chi^2 \times d^3 \times F_2 = 4 \times 27 \times 17 = 1836 \tag{15}$$

3.2 Comparison with Experiment

Source	Value	Error vs. Theory
Formula	1836 (exact)	—
CODATA 2022	1836.152 673 43(11)	0.0083%

Table 1: Proton-electron mass ratio: theory vs. experiment

Interpretation: The 0.008% deviation likely arises from:

- Binding energy corrections
- QED radiative corrections
- Strong force contributions

The integer 1836 may represent the *bare* or *topological* mass.

3.3 Machine-Verified Proof

Machine-Verified

Theorem 3.2 (Proton Formula Consistency)**.** *The formula is internally consistent:*

$$\begin{aligned} \textit{proton-mass-formula} &= \textit{spin-factor} \times \textit{winding}(3) \times F_2 && (16)\\ &= 4 \times 27 \times 17 && (17)\\ &= 1836 && (18) \end{aligned}$$

Proof. Direct computation verified by Agda's computational engine. Lines 7223–7227. □

3.4 Alternative Formulation

Machine-Verified

Theorem 3.3 (Proton Alternative)**.** *Using edge count directly:*

$$\frac{m_p}{m_e} = d \times E^2 \times F_2 = 3 \times 36 \times 17 = 1836 \tag{19}$$

Proof. Since $E = 6$ and $d^3 = 27 = d \times (d \times d) = d \times 9$, while $E^2 = 36 = 4 \times 9$, the formulas are equivalent modulo factorization. Lines 7233–7239. □

3.5 Exclusivity: Why This Combination?

Machine-Verified

Theorem 3.4 (Proton Exponent Uniqueness). *Among combinations of χ and d, only $\chi^2 \times d^3$ yields 1836:*

Exponents	*Formula*	*Result*	*Match?*
$\chi^2 \times d^3 \times F_2$	$4 \times 27 \times 17$	*1836*	✓
$\chi^1 \times d^3 \times F_2$	$2 \times 27 \times 17$	*918*	×
$\chi^3 \times d^2 \times F_2$	$8 \times 9 \times 17$	*1224*	×
$\chi^2 \times d^2 \times F_2$	$4 \times 9 \times 17$	*612*	×
$\chi^1 \times d^4 \times F_2$	$2 \times 81 \times 17$	*2754*	×

Proof. Exhaustive enumeration of small exponents. Lines 7254–7275. □

4 Muon Mass Ratio

4.1 The Formula

Physical Hypothesis

Hypothesis 4.1 (Muon Mass). The muon-electron mass ratio is:

$$\frac{m_\mu}{m_e} = d^2 \times 23 = 9 \times 23 = 207 \tag{20}$$

where:

$$23 = E + F_2 = 6 + 17 \tag{21}$$

4.2 Alternative Interpretation

The factor 23 has multiple derivations from K_4:

$$23 = E + F_2 = 6 + 17 \quad \text{(edge + alpha period)} \tag{22}$$

$$23 = 2V + d + \text{spinor-modes} = 8 + 4 + 3 \quad \text{(excitation channels)} \tag{23}$$

Machine-Verified

Theorem 4.2 (Muon Factor Equivalence). *Both derivations yield 23:*

$$E + F_2 = 2V + d + \textit{spinor-modes} = 23 \tag{24}$$

Proof. Lines 7285–7293. The equality is established by:

$$E + F_2 = 6 + 17 = 23 \tag{25}$$

$$2V + d + \text{spinor-modes} = 2(4) + 3 + 12 = 23 \tag{26}$$

where spinor-modes $= 12$ from K_4 representation theory. □

4.3 Comparison with Experiment

The 0.11% deviation is consistent with QED corrections and muon self-energy.

Source	Value	Error vs. Theory
Formula	207 (exact)	—
CODATA 2022	206.768 2830(46)	0.11%

Table 2: Muon-electron mass ratio: theory vs. experiment

4.4 Uniqueness

Machine-Verified

Theorem 4.3 (Muon Factorization Uniqueness). *The decomposition* $207 = 9 \times 23$ *is unique:*

$$207 = d^2 \times 23 \quad \textit{(valid)} \tag{27}$$

$$207 = d \times 69 \quad \textit{(but 69 not derivable from } K_4\textit{)} \tag{28}$$

Only $d^2 = 9$ *and factor* $23 = E + F_2$ *are* K_4*-derived.*

Proof. Lines 7301–7318. □

5 Tau Mass Ratio

5.1 The Formula

Physical Hypothesis

Hypothesis 5.1 (Tau Mass). The tau-electron mass ratio is:

$$\frac{m_\tau}{m_e} = F_2 \times \frac{m_\mu}{m_e} = 17 \times 207 = 3519 \tag{29}$$

Remark 5.2. The tau mass scales with muon mass by exactly F_2, the period derived in FD-02 (lines 6969–7026).

5.2 Comparison with Experiment

Source	Value	Error vs. Theory
Formula	3519 (exact)	—
CODATA 2022	3477.23(23)	1.2%

Table 3: Tau-electron mass ratio: theory vs. experiment

Note: The 1.2% deviation is larger than for proton and muon. Possible explanations:

- Stronger weak interaction corrections
- Higher-order loop effects
- Additional topological factors needed

5.3 Machine-Verified Proof

Machine-Verified

Theorem 5.3 (Tau Formula Consistency).

$$\textit{tau-mass-formula} = F_2 \times \textit{muon-mass-formula} = 17 \times 207 = 3519 \tag{30}$$

Proof. Lines 7319–7327. □

6 Neutron Mass Ratio

6.1 The Formula

Physical Hypothesis

Hypothesis 6.1 (Neutron Mass). The neutron-electron mass ratio is:

$$\frac{m_n}{m_e} = \frac{m_p}{m_e} + \chi = 1836 + 2 = 1838 \tag{31}$$

6.2 Comparison with Experiment

Source	Value	Error vs. Theory
Formula	1838 (exact)	—
CODATA 2022	1838.683 6605(11)	0.037%

Table 4: Neutron-electron mass ratio: theory vs. experiment

Remark 6.2. The neutron-proton mass difference $\Delta m = m_n - m_p \approx 2m_e$ is predicted exactly by $\chi = 2$.

6.3 Machine-Verified Proof

Machine-Verified

Theorem 6.3 (Neutron Formula).

$$\textit{neutron-mass-formula} = \textit{proton-mass-formula} + \chi = 1836 + 2 = 1838 \tag{32}$$

Proof. Lines 7276–7281. □

7 Validation via Four-Part Structure

Machine-Verified

Theorem 7.1 (Mass Ratio Four-Part Validation). *The mass formulas satisfy:*

1. ***Consistency:*** *All terms derived from K_4 invariants*
2. ***Exclusivity:*** *Alternative exponent combinations fail*
3. ***Robustness:*** *Multiple derivation paths agree (e.g., muon factor 23)*

4. ***Cross-Constraints:*** $\chi \cdot d = E$, $F_2 = 17$, *hierarchy preserved*

Proof. **Consistency:** Lines 7335–7348 prove all formulas use only K_4 invariants.

Exclusivity: Lines 7350–7362 enumerate alternative exponent choices; none match observations.

Robustness: Lines 7365–7377 show equivalent derivations (e.g., two proton formulas, two muon factors).

Cross-Constraints: Lines 7379–7393 verify interdependencies: $\chi d = E$, spin factor $= \chi^2$, tau-muon ratio $= F_2$. □

8 Summary of Predictions

Particle	Formula	Theory	Experiment
Proton	$\chi^2 d^3 F_2$	1836	1836.15
Neutron	$\chi^2 d^3 F_2 + \chi$	1838	1838.68
Muon	$d^2 \times 23$	207	206.77
Tau	$F_2 \times m_\mu/m_e$	3519	3477.23

Table 5: Mass ratio predictions vs. experiment (all ratios to electron mass)

Average deviation: $\sim 0.4\%$ across all particles.

9 Interpretation

9.1 What the Formulas Suggest

1. **Masses are combinatorial:** Determined by how K_4 structure "wraps" or "winds"
2. **Hierarchy is topological:** Proton ($\chi^2 d^3$) vs. muon (d^2) vs. tau ($F_2\times$ muon)
3. **Exponents matter:** χ^2 (spin?), d^2 (planar?), d^3 (spatial?)
4. **Integer formulas:** Suggest underlying discrete structure

9.2 What This Does Not Explain

- Why these specific particles exist (electron, muon, tau, proton, neutron)
- Quark masses (up, down, charm, etc.)
- W, Z, Higgs boson masses
- Fine corrections ($< 1\%$ deviations)

9.3 Open Questions

1. Can quark masses be derived from K_4 with additional topological factors?
2. Does the exponent pattern ($\chi^2 d^3$, d^2, etc.) encode quantum numbers?
3. Are the $< 1\%$ deviations predictable from perturbative corrections?
4. Can gauge boson masses emerge from K_4 spectral properties?

10 Experimental Tests

10.1 Falsification Criteria

The hypothesis fails if:

1. A particle is discovered with mass ratio *incompatible* with any K_4 formula
2. Precision measurements deviate beyond what QED/QCD corrections predict
3. The pattern breaks down for heavier generations (e.g., hypothetical 4th generation)

10.2 Supportive Evidence

- All observed leptons (e, μ, τ) match predictions within $\sim 1\%$
- Proton and neutron ratios match within $< 0.1\%$
- Integer structure suggests no fine-tuning

11 Comparison with Other Approaches

11.1 Standard Model

- **SM:** Masses from Yukawa couplings (19 free parameters)
- **FD:** Masses from K_4 topology (0 free parameters, modulo exponents)

11.2 String Theory

- **Strings:** Masses from compactification geometry (many possibilities)
- **FD:** Masses from single forced graph K_4

11.3 Preon Models

- **Preons:** Composite particles from sub-constituents
- **FD:** Combinatorial patterns from graph topology (no sub-structure needed)

12 Related Work

- **Koide formula (1982):** $m_e + m_\mu + m_\tau = \frac{2}{3}(\sqrt{m_e} + \sqrt{m_\mu} + \sqrt{m_\tau})^2$
- **Barut formulas (1979):** Electromagnetic mass formulas for leptons
- **Rishon model (1979):** Preon theory with combinatorial masses
- **Topological mass generation:** MacDowell-Mansouri gravity, Chern-Simons theories

Our contribution: derivation from minimal forced structure (K_4), machine-verified.

13 Implications

13.1 What Is Proven

1. Formulas $\chi^2 d^3 F_2 = 1836$, $d^2 \times 23 = 207$, etc. are correct (pure math)
2. All terms are K_4 invariants (verified in Agda)
3. Alternative combinations fail to match observations

13.2 What Is Hypothesized

1. These formulas correspond to physical particle masses
2. The $< 1\%$ deviations are explainable by known corrections
3. The pattern extends to other particles (potentially)

13.3 Philosophical Implications

If accepted:

- Mass is not fundamental—it is a combinatorial property
- Particle taxonomy reflects graph topology
- The mass hierarchy is not arbitrary

14 Verification

14.1 How to Verify

```
git clone https://github.com/de-johannes/FirstDistinction.git
cd FirstDistinction
agda --safe --without-K FirstDistinction.agda
```

Check lines 7197–7400 for mass ratio proofs.

14.2 Proof Statistics

Metric	Value
Total lines	7,938
Winding factors	Lines 7197–7210
Proton formula	Lines 7217–7239
Neutron formula	Lines 7276–7281
Muon formula	Lines 7285–7318
Tau formula	Lines 7319–7327
Four-part validation	Lines 7335–7400
Axioms	0
Postulates	0

15 Conclusion

We have proposed mass ratio formulas derived exclusively from K_4 topology:

- Proton: $m_p/m_e = \chi^2 d^3 F_2 = 1836$ (error 0.008%)
- Muon: $m_\mu/m_e = d^2 \times 23 = 207$ (error 0.11%)
- Tau: $m_\tau/m_e = F_2 \times 207 = 3519$ (error 1.2%)
- Neutron: $m_n/m_e = 1836 + 2 = 1838$ (error 0.037%)

The formulas are machine-verified. The physical correspondence is a testable hypothesis.

If correct, particle masses are not free parameters—they are determined by the combinatorial structure of the minimal forced graph.

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References

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