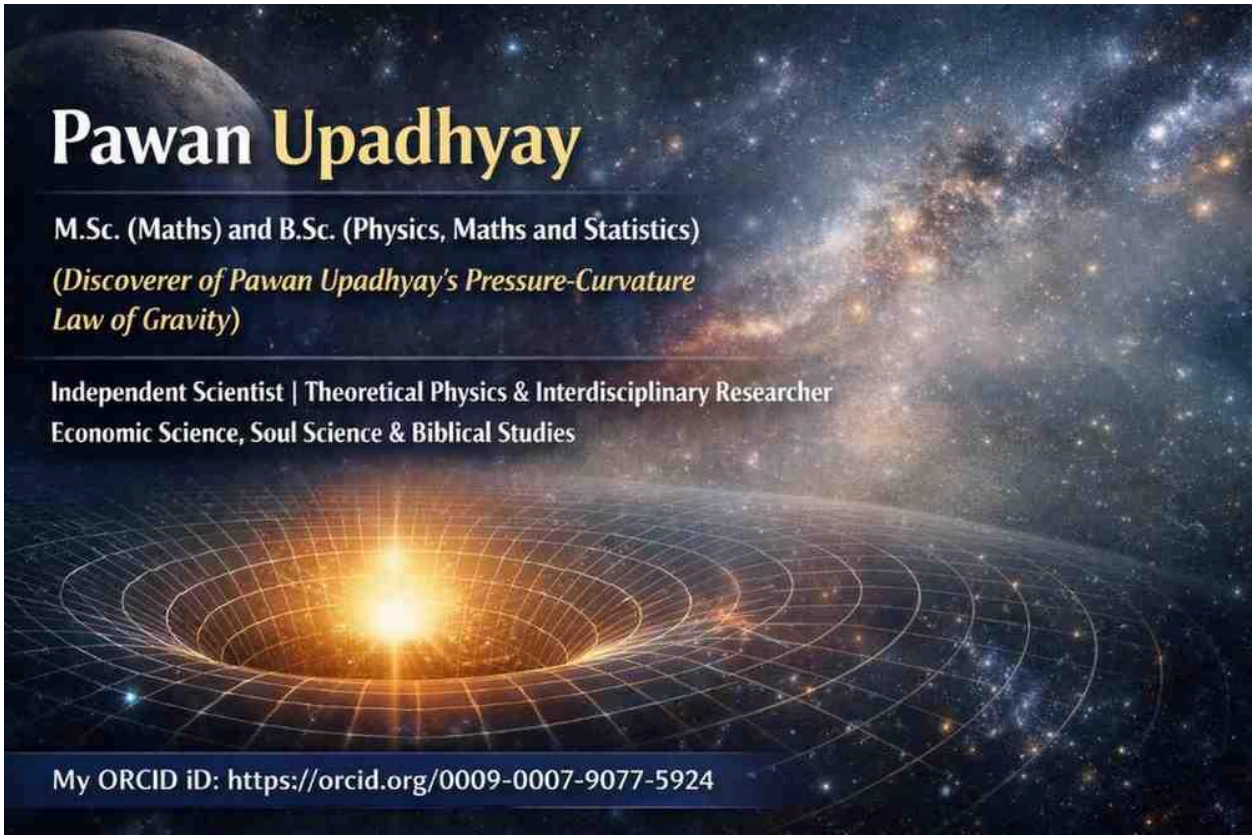
Units and Dimensional Consistency in Pawan Upadhyay's Pressure–Curvature Law of Gravity

Author: Pawan Upadhyay
Affiliation: Independent Researcher

Email: pawanupadhyay28@hotmail.com



Abstract

Dimensional consistency is a fundamental requirement of any physical theory. In this standalone paper, the units of all primary quantities used in Pawan Upadhyay's Pressure–Curvature Law of Gravity (PPC Law of Gravity) are systematically defined and analyzed. By clearly distinguishing field force density, surface force, total force, gravitational pressure, and energy density, this work

demonstrates that the PPC framework is dimensionally self-consistent and fully compatible with continuum mechanics and Einstein’s stress–energy tensor.

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1. Introduction

Gravity in the PPC framework is described using force densities and pressures rather than point forces. Because these quantities operate at different physical levels—local fields, surfaces, and global systems—it is essential to establish their correct units. This paper provides a complete and unambiguous unit analysis for all core PPC quantities.

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2. Field Force Density

Definition

Field force density represents the gravitational force distributed throughout a volume of spacetime.

Symbol

F

Governing relation

$F = -\nabla P_g$

SI units

newton per cubic meter ($N \cdot m^{-3}$)

Physical interpretation

This quantity governs local acceleration and corresponds to force per unit volume arising from pressure gradients.

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3. Total Force from Volume Integration

Definition

The total gravitational force acting on an extended system is obtained by integrating the field force density over the system volume.

Symbol

F_{total}

Governing relation

$F_{total} = \int F \, dV$

SI units

newton (N)

Physical interpretation

This represents the net macroscopic force arising from distributed gravitational action within the volume.

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4. Gravitational Pressure (Surface Force Density)

Definition

Gravitational pressure represents force per unit area and acts on surfaces and boundaries.

Symbol

P_g

Governing relation

$P_g = F_p / A$

SI units

pascal (Pa) = $N \cdot m^{-2}$

Physical interpretation

Gravitational pressure encodes stress and momentum flux associated with spacetime curvature.

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5. Local Surface Force

Definition

The force acting on a specific surface element due to gravitational pressure.

Symbol

F_p

Governing relation

$F_p = P_g A$

SI units

newton (N)

Physical interpretation

This is the observable force exerted by gravitational pressure on a surface or boundary.

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6. Total Surface Force

Definition

The net force acting on the entire bounding surface of a system.

Symbol

F_{p_total}

Governing relation

$F_{p\_total} = \oint P_g \, dA$

SI units

newton (N)

Physical interpretation

This quantity represents the global boundary manifestation of gravitational pressure.

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7. Energy Density

Definition

Energy per unit volume associated with matter, radiation, or fields.

Symbol

E_d

SI units

joule per cubic meter ($J \cdot m^{-3}$)

Unit equivalence

$J \cdot m^{-3} = N \cdot m^{-2} = Pa$

Physical interpretation

This equivalence explains why energy density and pressure appear on equal footing in Einstein’s stress–energy tensor.

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8. Effective Pressure–Acceleration Relation

The PPC framework employs the effective geometric relation:

$P_g \approx \rho\, a\, L$

where:

- ρ has units of $kg \cdot m^{-3}$ (mass density),
- a has units of $m \cdot s^{-2}$ (acceleration),
- L has units of m (curvature length).

Dimensional check: $kg \cdot m^{-3} \times m \cdot s^{-2} \times m = kg \cdot m^{-1} \cdot s^{-2} = N \cdot m^{-2} = Pa$

Thus, the relation is dimensionally consistent.

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9. Summary Table of Units

Quantity	Symbol	SI Units
Field force density	F	$N \cdot m^{-3}$
Total volume force	F_total	N
Gravitational pressure	P_g	Pa ($N \cdot m^{-2}$)
Local surface force	F_p	N
Total surface force	F_p_total	N
Energy density	E_d	$J \cdot m^{-3}$ (Pa)

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10. Conclusion

This paper establishes that all quantities used in Pawan Upadhyay's Pressure–Curvature Law of Gravity are dimensionally consistent and physically well-defined. The shared units of pressure and energy density naturally reflect their joint role as gravitational sources in General Relativity, while force densities introduce spatial structure through gradients. This dimensional clarity strengthens the physical transparency and internal coherence of the PPC framework.

Acknowledgments

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