% ==========================================================

% UMCP / RCFT / ULRC — CONSISTENT PAPER TEMPLATE (REVTeX)

% Version: 2025-08-31 (America/Chicago)

% Notes:

% • Idempotent macros: safe to reuse; avoids double-script collisions.

% • Covers all core equations, closures, welds, regimes, typed outcomes.

% • Replace TODO: blocks with your content.

% ==========================================================

\documentclass[reprint,onecolumn,amsmath,amssymb,11pt,aps,prx]{revtex4-2}

% ==============================

% Niceties + Math Foundations

% ==============================

\usepackage{microtype}

\usepackage{mathtools} % extends amsmath

\usepackage{bm} % bold math

\usepackage{siunitx} % units

% ------------------------------

% Paired delimiters (safe, consistent)

% ------------------------------

\DeclarePairedDelimiter\abs{\lvert}{\rvert}

\DeclarePairedDelimiter\floor{\lfloor}{\rfloor}

\DeclarePairedDelimiter\ceil{\lceil}{\rceil}

\DeclarePairedDelimiter\paren{\lparen}{\rparen}

\DeclarePairedDelimiter\brak{\lbrack}{\rbrack}

\DeclarePairedDelimiter\set{\lbrace}{\rbrace}

% ------------------------------

% Core sets, operators, indicators (idempotent)

% ------------------------------

\providecommand{\R}{\mathbb{R}}

\providecommand{\E}{\mathbb{E}}

\providecommand{\Var}{\operatorname{Var}}

\providecommand{\sgn}{\operatorname{sgn}}

\providecommand{\diag}{\operatorname{diag}}

\providecommand{\1}{\mathbf{1}} % vector of ones

\newcommand{\Ind}[1]{\mathbf{1}\!\set\*{#1}} % indicator {…}

\newcommand{\norm}[1]{\left\lVert #1 \right\rVert}

\newcommand{\hash}{\texttt{sha256}}

% ------------------------------

% Small helpers (operators)

% ------------------------------

\providecommand{\clip}{\operatorname{clip}}

\providecommand{\EMA}{\operatorname{EMA}}

% ==============================

% UMCP / RCFT / ULRC Canon Macros

% ==============================

% ---- Constants and switches (symbols; values set in text/tables)

\newcommand{\eps}{\varepsilon} % numerical floor in S(ω)

\newcommand{\alphaIC}{\alpha} % IC curvature weight

\newcommand{\Kcurv}{K} % curvature window size

\newcommand{\lambdaEMA}{\lambda} % EMA memory

\newcommand{\kret}{k} % return tolerance multiplier

\newcommand{\epsmin}{\varepsilon\_{\min}} % ε\_min

\newcommand{\epsmax}{\varepsilon\_{\max}} % ε\_max

\newcommand{\lambdaWall}{\lambda\_{\text{wall}}}

% ---- Reentry delay (collision-free)

\newcommand{\taur}{\tau\_{\!R}} % τ\_R

\newcommand{\taurt}{\tau\_{\!R,t}} % τ\_{R,t}

\newcommand{\tauri}[1]{\tau\_{\!R,#1}} % τ\_{R,<arg>}

\newcommand{\epsret}{\varepsilon\_{\mathrm{ret}}} % ε\_ret

\newcommand{\sigman}{\sigma\_{\!n}} % EMA noise for ε\_ret

% ---- Normalization & clipping

\newcommand{\affmap}[1]{\frac{#1 - a}{b}} % y = (x-a)/b

\newcommand{\xhat}{\hat{x}} % \hat{x}

\newcommand{\xhatT}[1]{\hat{x}\_{#1}} % \hat{x}\_t

% ---- Invariants (variables)

\newcommand{\w}{\omega} % drift ω

\newcommand{\Fid}{F} % fidelity F = 1 - ω

\newcommand{\Ent}{S} % entropy S = -ln(1-ω+ε)

\newcommand{\Curv}{C} % curvature C

\providecommand{\IC}{\mathrm{IC}} % integrity IC (upright)

\newcommand{\kap}{\kappa} % κ = ln(IC)

% ---- Faces for drift (policies)

\newcommand{\omegapre}[2]{\abs\*{#1 - #2}} % pre-clip face: |y\_t - y\_{t-1}|

\newcommand{\omegapost}[2]{\abs\*{#1 - #2}} % post-clip face: |\hat x\_t - \hat x\_{t-1}|

% ---- Canonical formulas (boxed as macros to prevent script errors)

% Entropy: S(ω) = -ln(1 - ω + ε)

\newcommand{\Sof}[1]{-\ln\!\paren\*{1 - #1 + \eps}}

% Fidelity: F(ω) = 1 - ω

\newcommand{\Fof}[1]{1 - #1}

% Curvature payload U := C/(1 + τ\_R)

\newcommand{\Upayload}{U}

\newcommand{\Uof}[2]{\frac{#1}{1 + #2}} % U(C, τ\_R)

% K-factor for IC: K = exp( -α C/(1 + τ\_R) )

\newcommand{\Kfac}[2]{\exp\!\paren\*{-\alphaIC\,\frac{#1}{1 + #2}}}

% Integrity: IC(ω,C,τ\_R) = (1-ω)^2 \* e^{-S(ω)} \* exp(-α C/(1+τ\_R))

\newcommand{\ICof}[3]{\paren\*{1-#1}^2 \exp\!\paren\*{-\Sof{#1}} \Kfac{#2}{#3}}

% Log-integrity: κ = ln IC

\newcommand{\kapof}[3]{\ln\!\paren\*{\ICof{#1}{#2}{#3}}}

% Return tolerance: ε\_ret = clip(k·σ\_n, ε\_min, ε\_max)

\newcommand{\epsretOf}[1]{\clip\!\paren\*{\kret #1,\, \epsmin,\, \epsmax}}

% Curvature (K-window): C\_t = (1/K) Σ\_{k=1..K} (x̂\_t − x̂\_{t−k})²

% Usage at time t: \Curvof{\Kcurv}{\xhatT{t}}{\xhatT{t-k}} (with "use available terms" understood).

\newcommand{\Curvof}[3]{\frac{1}{#1} \sum\_{k=1}^{#1} \paren\*{#2 - #3}^2}

% ---- Aggregators and regime gates

\newcommand{\ICagg}{\IC\_{\mathrm{agg}}}

\newcommand{\GeoMean}[2]{\prod\_{i=1}^{#1} \IC\_i^{\,w\_i}} % geometric mean with weights w\_i

\newcommand{\Stable}{\textsc{Stable}}

\newcommand{\Watch}{\textsc{Watch}}

\newcommand{\Collapse}{\textsc{Collapse}}

\newcommand{\Critical}{\textsc{Critical}}

\newcommand{\thw}{\theta\_{\omega}}

\newcommand{\thF}{\theta\_{F}}

\newcommand{\thS}{\theta\_{S}}

\newcommand{\thC}{\theta\_{C}}

% ---- Regime ODE / CTMC generator (column convention)

\newcommand{\Q}{\mathbf{Q}}

\newcommand{\ones}{\mathbf{1}}

\newcommand{\ctmcCons}{\ones^{\!\top}\!\Q = \mathbf{0},\ \ Q\_{ij}\!\ge 0\ (i\neq j)}

% ---- Secant face + transport identities

\newcommand{\facepot}{\Phi}

\newcommand{\gammasec}[1]{\Gamma^{\mathrm{sec}}\_{#1}} % Γ^{sec}\_t

\newcommand{\Ut}{\Upayload\_t}

% ---- Typed outcomes (fail-closed)

\newcommand{\oor}{\perp\_{\!\mathrm{oor}}} % out-of-range typed value

\newcommand{\inftyrec}{\infty\_{\mathrm{rec}}} % division-by-zero typed value

\newcommand{\roor}{r\_{\mathrm{oor}}} % OOR rate

% ---- Weld headers and continuity

\newcommand{\WeldID}[1]{\texttt{W-#1}}

\newcommand{\kapCont}{\abs\*{\kap\_{t^+}-\kap\_{t^-}}\le \text{tol}\_W}

\newcommand{\UCont}{\abs\*{\Upayload\_{t^+}-\Upayload\_{t^-}}\le \text{tol}\_T}

% ==============================

% Color + Branding (optional)

% ==============================

\usepackage{xcolor}

\definecolor{UMCPAccent}{HTML}{337799}

\colorlet{UMCPAccentDark}{UMCPAccent!80!black}

\colorlet{UMCPAccentLight}{UMCPAccent!30!white}

\colorlet{UMCPAccentFaint}{UMCPAccent!12!white}

\newcommand{\umcp}[1]{\textcolor{UMCPAccent}{#1}}

\newcommand{\divider}{\par\medskip\noindent\textcolor{UMCPAccent}{\rule{\linewidth}{0.4pt}}\medskip\par}

% ORCID (package if present; otherwise fallback)

\IfFileExists{orcidlink.sty}{\usepackage{orcidlink}}{%

\newcommand{\orcidlink}[1]{\href{https://orcid.org/#1}{ORCID}}%

}

\newcommand{\AuthorORCID}{0009-0000-6069-8234}

% ==============================

% Hyperref — LOAD LAST

% ==============================

\usepackage[colorlinks=true]{hyperref}

\hypersetup{

linkcolor=UMCPAccent,

urlcolor=UMCPAccent,

citecolor=UMCPAccent

}

% ==============================

% Theorem-like environments (optional)

% ==============================

\newtheorem{identity}{Identity}

\newtheorem{theorem}{Theorem}

\newtheorem{lemma}{Lemma}

\newtheorem{proposition}{Proposition}

\newtheorem{definition}{Definition}

% ==============================

% Meta footer line

% ==============================

\newcommand{\Metaline}[1]{\textit{Meta}—#1.}

% ==========================================================

% DOCUMENT

% ==========================================================

\begin{document}

\title{TITLE GOES HERE: Concise, Specific, and UMCP/RCFT/ULRC Aligned}

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\email{clementpaulus9@gmail.com}

\date{August 31, 2025 (America/Chicago)} % Use explicit absolute date in America/Chicago

\begin{abstract}

% TODO: 4–6 sentences. Contract-first statement, core result, what is invariant,

% what is closure, what changed (data/evidence), and what the audit exports.

This work formalizes a contract-first, weld-continuous calculus for collapse invariants

$(\w,\Fid,\Ent,\Curv,\taur,\IC)$ and their regime map. Identities are separated from closures,

and all outputs are audit-ready.

\end{abstract}

\maketitle

\divider

% ==========================================================

\section{Governance Contract (Freeze-First)}

% ==========================================================

% TODO: Fill with actual (a,b), face policy, epsilon, K, α, λ, k, ε\_min, ε\_max, tol\_W, tol\_T.

We freeze the affine map $y=\affmap{x}$ with $b>0$ and clip $\xhat=\clip(y,0,1)$.

Active face policy: pre-clip, pivot to post-clip+guard near walls (log $\lambdaWall$).

Typed outcomes: domain $\Rightarrow \oor$, division-by-zero $\Rightarrow \inftyrec$.

Published tolerances: $\text{tol}\_W, \text{tol}\_T$.

Time zone: America/Chicago (absolute dates).

\begin{table}[h]

\caption{Frozen closures and defaults (edit as needed).}

\begin{ruledtabular}

\begin{tabular}{l l}

Numerical floor & $\eps = 10^{-8}$ \\

Curvature window & $\Kcurv = 3$ \\

IC curvature weight & $\alphaIC = 1$ \\

EMA memory & $\lambdaEMA = 0.2$ \\

Return tolerance & $\epsret = \clip(\kret \sigman,\epsmin,\epsmax)$;\; $\kret=2.5$, $\epsmin=5\cdot10^{-4}$, $\epsmax=0.07$ \\

OOR policy & clip\\_and\\_flag;\; OOR rate $\roor$ reported \\

Regime gates & $\Stable:\w<0.038,\ \Fid>0.90,\ \Ent<0.15,\ \Curv<0.14$;\; $\Watch:0.038\text{–}0.30$;\; $\Collapse:\ge 0.30$ \\

CTMC generator & column convention; \ $\ctmcCons$ \\

\end{tabular}

\end{ruledtabular}

\end{table}

% ==========================================================

\section{Invariants (Identities)}

% ==========================================================

Given $\xhat\_t\in[0,1]$ and frozen $(a,b)$:

\begin{align}

\w\_t &= \omegapre{y\_t}{y\_{t-1}} \quad \text{(pre-clip; else post-clip: }\omegapost{\xhat\_t}{\xhat\_{t-1}}\text{)} \\

\Fid\_t &= \Fof{\w\_t} \\

\Ent\_t &= \Sof{\w\_t} \\

\Curv\_t &= \frac{1}{\Kcurv}\sum\_{k=1}^{\Kcurv}\left(\xhat\_t-\xhat\_{t-k}\right)^2 \\

\epsret\_t &= \epsretOf{\sigman(t)},\qquad \taurt = \min\{\Delta t>0:\abs{\xhat\_t-\xhat\_{t-\Delta t}}<\epsret\_t\} \\

\IC\_t &= \ICof{\w\_t}{\Curv\_t}{\taurt},\qquad \kap\_t=\ln \IC\_t

\end{align}

\begin{identity}[Geometric Mean Aggregator]

Let $\{\IC\_i\}\_{i=1}^m\subset(0,1]$ with weights $w\_i\ge0$, $\sum\_i w\_i=1$. Then

$\ICagg=\prod\_{i=1}^m \IC\_i^{\,w\_i}\in(0,1]$ is non-decreasing in each $\IC\_i$ and log-concave.

\end{identity}

\begin{identity}[Weld Continuity]

At declared anchor $t=\hat t$, enforce $\kapCont$ and $\UCont$ with $\Upayload:=\Uof{\Curv}{\taur}$.

\end{identity}

% ==========================================================

\section{Closures (Policies) and Sensitivities}

% ==========================================================

Closures are published knobs; identities do not depend on them.

We track sensitivities $\partial \kap/\partial \w,\ \partial \kap/\partial \Curv,\ \partial \kap/\partial \taur$

to surface operator effects.

% ==========================================================

\section{Data and Runbook}

% ==========================================================

% TODO: Brief datasets, provenance, and run steps.

\textbf{/ingest} → \textbf{/freeze} → \textbf{/compute} → \textbf{/regime} → \textbf{/render} → \textbf{/export}.

% ==========================================================

\section{Results and Regime Map}

% ==========================================================

% TODO: Summaries, figures, and tables.

Label per-timestep regimes by worst-of gates (ties broken by larger $\IC$). Multi-channel

integrity via $\ICagg$.

\begin{table}[h]

\caption{Sample audit row (schema).}

\begin{ruledtabular}

\begin{tabular}{l}

$[t,\ \text{channel},\ x\_{\text{raw}},\ a,\ b,\ y,\ \xhat,\ \w,\ \Fid,\ \Ent,\ \Curv,\ \taur,\ \IC,\ \text{regime},\ \text{weld\\_id?},\ \text{policy\\_id},\ \text{manifest\\_id},\ \text{run\\_id},\ \hash]$ \\

\end{tabular}

\end{ruledtabular}

\end{table}

% ==========================================================

\section{Welds, Typed Outcomes, and Near-Wall Policy}

% ==========================================================

Weld headers report $\WeldID{...}$, anchor time, manifest IDs, and measured $\Delta \kap$.

Typed outcomes $\oor$ and $\inftyrec$ are first-class and retained in the audit.

Pivot to post-clip+guard near walls; log $\lambdaWall$ and OOR rate $\roor$.

% ==========================================================

\section{Meta Line (Example)}

% ==========================================================

\Metaline{Tags:\,UMCP; Slice:[$t\_0,t\_1$]; Contract:\,$(a,b,\eps)=(\cdot,\cdot,10^{-8})$;

Bands:\,Defaults; Ops:\,$\w$=pre-clip, IC=normal($p{=}3$), $\Kcurv{=}3$, $\alphaIC{=}1$, $\lambdaEMA{=}0.2$, $k{=}2.5$;

$Q$:\,column, $\ones^\top Q {=} 0$; Norm:\,global\\_fixed; OOR:\,clip\\_and\\_flag; TZ:\,America/Chicago;

Manifest:\,\texttt{<id>}; Weld:\,\texttt{<id?>}; Hash:\,\hash}

% ==========================================================

\section\*{Acknowledgments}

% TODO

% ==========================================================

\bibliographystyle{apsrev4-2}

\bibliography{refs} % Create refs.bib in the project

\end{document}