IEEE 9-Bus Validation Report

Physics-Informed Neural Networks for Power Flow

Validated against exact analytical & Newton-Raphson solutions

Metric	Result
Ground-truth balance residual	1.11e-16 (machine precision)
DC PINN — RMSE vs analytical	0.0124 deg
DC PINN — max bus error	0.0188 deg
AC PINN — angle RMSE	0.0035 deg
AC PINN — voltage RMSE	3.43e-05 p.u.
N-1 contingency secure	6 / 9 single-line outages

Reproducibility

```
pip install -e .  &&  python -m physics_informed_grid.validate_ieee9
```

Every figure is seed-fixed and deterministic. 21 automated tests pass.

AC Power Flow — PINN vs Newton-Raphson

Bus	|V| PINN	|V| true	angle PINN	angle true
1	1.0400	1.0400	+0.000	+0.000
2	1.0250	1.0250	+10.014	+10.010
3	1.0250	1.0250	+4.684	+4.680
4	1.0236	1.0237	-2.242	-2.243
5	0.9921	0.9920	-4.811	-4.809
6	1.0298	1.0298	+1.971	+1.975
7	1.0193	1.0194	+1.394	+1.394
8	1.0290	1.0290	+4.465	+4.467
9	1.0064	1.0064	-2.998	-2.993