

Supplementary Information

Acquiring a new physical law from a quarter of the data: sample-efficient transfer in physics transformers

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SI 1. Per-seed few-shot results

Table 1 lists the three seeds for the headline conditions (from the committed eval files); Table 2 lists the three seeds of each transfer ablation (from `transfer_ablations.json`).

Table 1: Headline conditions, per seed.

	seed 0	seed 1	seed 2
generalist (conditioned) answer	0.197	0.287	0.182
generalist (control) answer	0.239	0.437	0.153
specialist answer	0.279	0.580	0.691
generalist (conditioned) curve	0.137	0.134	0.172
specialist curve	0.273	0.284	0.282

Table 2: Transfer ablations, per seed (answer error).

Variant	seed 0	seed 1	seed 2	median
full (conditioned)	0.197	0.287	0.182	0.197
no quantity vocabulary	0.666	2.022	14.477	2.022
no physics residual	0.214	0.332	0.161	0.214
frozen attention	0.185	0.198	0.282	0.198

SI 2. The trajectory effect of the physics residual

The physics-residual ablation is the surprising cell of the study, so it is verified twice: the committed ablation run and an independent re-run with a different batch-order seed give consistent trajectory errors (0.019–0.021 without the residual vs. 0.137–0.139 with it, seed 0). The effect is interpreted in the main text as the residual constraining the trajectory head toward the pretraining regime at 24-sample budgets; the residual’s scalar effect is small and direction-inconsistent, matching the companion loss-channel result that the loss channel buys consistency, not accuracy.

SI 3. Protocol details

Pretraining: 5 laws (beam, projectile, pendulum, spring, rc), 96 samples/law, 250 epochs, 6 seeds (seeds 0–2 used here). Adaptation: cantilever, 24 samples (seed 300 stream), 40 epochs, lr 10^{-3} , $w_{\text{phys}} = 0.05$ (or 0 for the ablation). Evaluation: 12 held-out cantilever samples (seed 100 stream protocol), answer rel-MAE and shape-normalized curve RMSE. The held-out law never appears in pretraining.

SI 4. Reproducibility

```
python3 physx/train_fewshot.py --law real --seed 0 --stage ft
python3 physx/run_transfer_ablations.py
python3 -m unittest physx.test_physx          # 49 tests incl. few-shot test
```