Model Testing: Froude and Reynolds Similarity Scaling

Model speed and the scale ratios of velocity, discharge, time, force and power for Froude or Reynolds similarity, and the prototype force from a model test.

Method: Dimensional analysis and similitude

Input parameters

Unit system: SI

Parameter	Value	Unit
Length scale (prototype / model)	25.000	
Prototype velocity	5.0000	m/s
Density ratio (prototype / model fluid)	1.0250	
Similarity law	Froude (gravity, free surface)	
Force measured on the model	0.012000	kN

Calculated results

Parameter	Value	Unit
Model velocity	1.0000	m/s
Velocity ratio	5.0000	
Discharge ratio	3,125.0	
Time ratio	5.0000	
Force ratio	16,016	
Power ratio	80,078	
Prototype force	192.19	kN

Notes for this case

• Dynamic similarity needs the governing dimensionless group equal in model and prototype. Equal Froude number V/√(gL) (ships, spillways, waves) gives V_r = λ^½, Q_r = λ^2.5, T_r = λ^½ and, with density ratio ρ_r, F_r = ρ_rλ³ and P_r = ρ_rλ^3.5. Equal Reynolds number VL/ν in the same fluid gives V_r = 1/λ, which needs impractically high model speeds, so ship models match Froude number and correct friction separately (ITTC). Forces scale as ρV²L².

Formula and method

$$\text{Froude}: \; V_r = \lambda^{1/2},\; F_r = \rho_r \lambda^3; \quad \text{Reynolds}: \; V_r = \lambda^{-1},\; F_r = \rho_r$$

Variables

λ	Length scale (prototype / model)	-
V_p	Prototype velocity	m/s
ρ_p/ρ_m	Density ratio (prototype / model fluid)	-
law	Similarity law	-
F_m	Force measured on the model	N
V_m	Model velocity	m/s
V_p/V_m	Velocity ratio	-
Q_p/Q_m	Discharge ratio	-
T_p/T_m	Time ratio	-
F_p/F_m	Force ratio	-

P_p/P_m	Power ratio	-
F_p	Prototype force	N

Method and standards

Similitude.

Assumptions and limits

- Geometric similarity; one dominant dimensionless group.

References

Dimensional analysis and similitude

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/mechanical/fluid-mechanics/model-similitude-scaling

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