Hydrostatic Force and Centre of Pressure on a Submerged Plate

Resultant hydrostatic force and centre of pressure on a rectangular, circular or triangular plate, vertical or inclined, such as a gate or a tank wall panel.

Method: Hydrostatic force on plane surfaces and the centre of pressure

Input parameters

Unit system: SI

Parameter	Value	Unit
Plate shape	Rectangle (width b, height h along the slope)	
Width or base	2.0000	m
Height along the slope, or diameter	1.5000	m
Distance along the slope from the free surface to the top edge	1.0000	m
Plate angle from the horizontal (90° vertical)	90.000	°
Liquid density	1,000.0	kg/m³
Gauge pressure on the free surface	0	kPa

Calculated results

Parameter	Value	Unit
Plate area	3.0000	m²
Vertical depth of the centroid	1.7500	m
Resultant force	51.485	kN
Centre of pressure along the slope from the free surface	1.8571	m
Vertical depth of the centre of pressure	1.8571	m
Distance of the centre of pressure below the centroid (along the slope)	107.14	mm
Moment about the top edge (hinge)	44.130	kN·m

Notes for this case

• F = (p₀ + ρgh_c)A; the centre of pressure lies I_c/(y_c A) below the centroid along the slope, where y_c is measured from the free surface (raised by p₀/ρg when the surface is pressurised). Atmospheric pressure acting on both sides is left out.

Formula and method

$$F = (p_0 + \rho g h_c) A, \quad h_c = y_c \sin\theta$$

$$y_{cp} = y_c + \frac{I_c}{y_c A} \quad (y \text{ measured along the plate from the free surface})$$

Variables

shape	Plate shape	-
b	Width or base	m
h	Height along the slope, or diameter	m
s	Distance along the slope from the free surface to the top edge	m
θ	Plate angle from the horizontal (90° vertical)	rad
ρ	Liquid density	kg/m³

p_0	Gauge pressure on the free surface	Pa
A	Plate area	m²
h_c	Vertical depth of the centroid	m
F	Resultant force	N
y_{cp}	Centre of pressure along the slope from the free surface	m
h_{cp}	Vertical depth of the centre of pressure	m
$y_{cp} - y_c$	Distance of the centre of pressure below the centroid (along the slope)	m
M_{top}	Moment about the top edge (hinge)	N·m

Method and standards

Hydrostatic resultant on a plane surface.

Assumptions and limits

- Static incompressible liquid; plane surface; atmospheric pressure on both sides.

References

Hydrostatic force on plane surfaces and the centre of pressure

Report details

Report reference	FCC-MFVK-J1GG (the same inputs always give the same reference)
Generated	23 November 2026, 17:50 UTC
Calculator	Hydrostatic Force and Centre of Pressure on a Submerged Plate
Method last reviewed	17 November 2026
Software release	FireCAD Calc, release of 22 November 2026
Release checks	4 reference cases of this calculator, computed independently, are checked on every release

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/submerged-plane-hydrostatic-force

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Reopens the calculator with the inputs of this report.