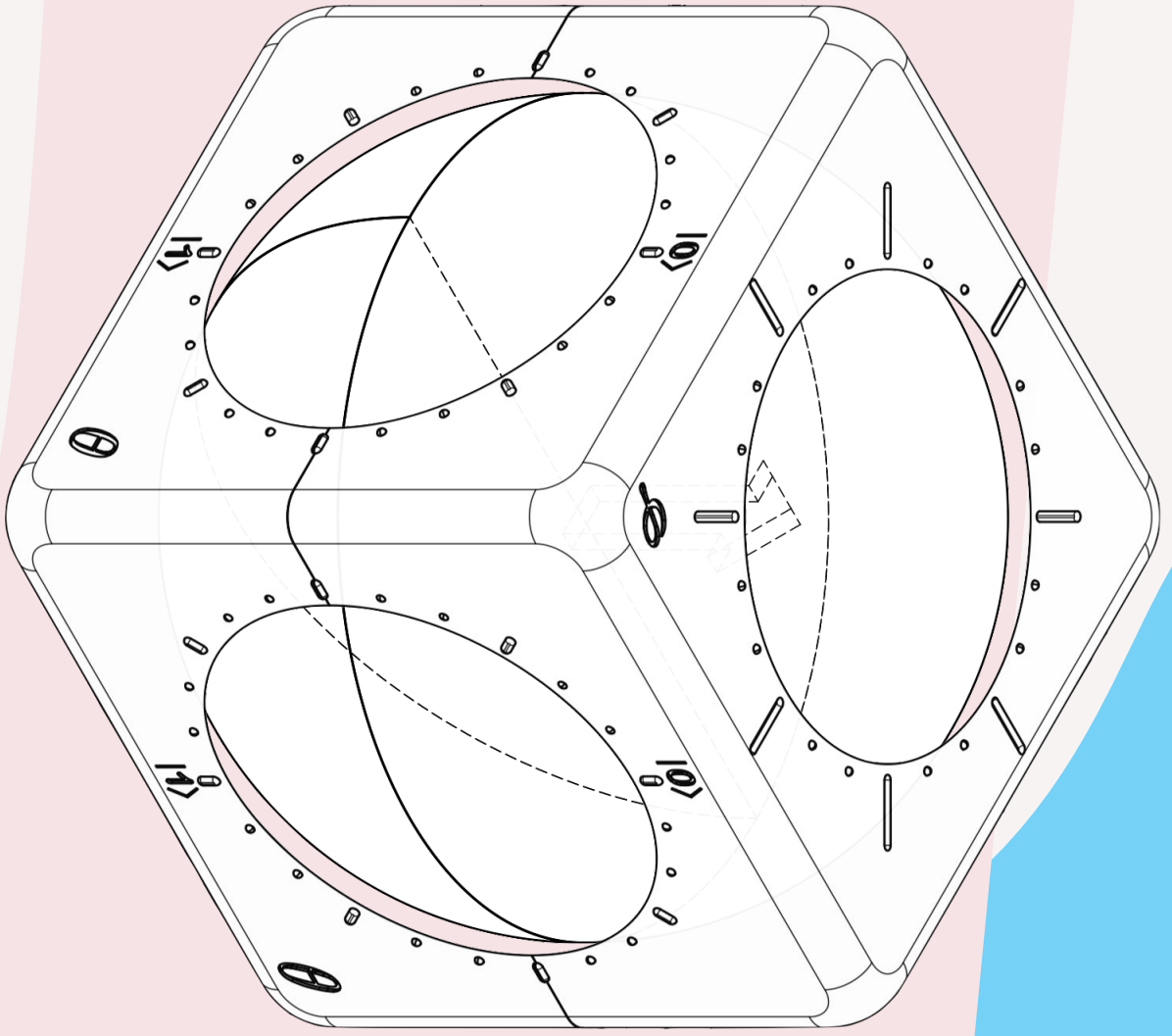
PORTABLE QUBIT

USER MANUAL



QUBIT ABACUS USER MANUAL

How to use the abacus to simulate a single-qubit quantum computer

1 PERFORM GATES

Simulate quantum computation on qubit by performing gate rotations on the assembly

2 READ STATES

Read qubit state by reading vector angles for measurement

3 FIND OUTCOME

Input qubit state information into MeasureApp on website and collapse the superposition into either 1 or 0

HOW TO READ STATES

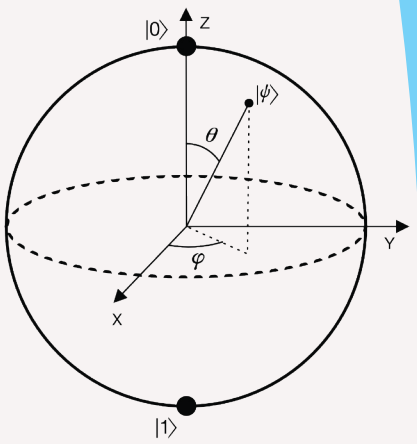
A **single-qubit quantum state** can be written as

$$|\psi\rangle = \cos\frac{\theta}{2}|0\rangle + e^{i\varphi}\sin\frac{\theta}{2}|1\rangle$$

where **the probability of measuring the state as |0⟩** = $\left(\cos\frac{\theta}{2}\right)^2$

where **the probability of measuring the state as |1⟩** = $\left(\sin\frac{\theta}{2}\right)^2 = 1-\left(\cos\frac{\theta}{2}\right)^2$

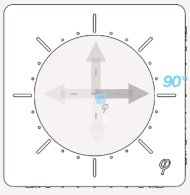
The **relative phase** = φ



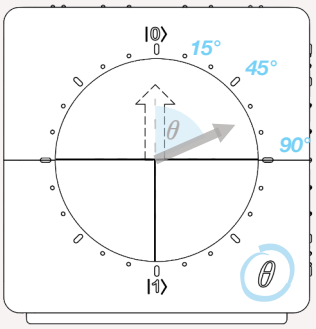
The angle φ can be measured by reading the angle of the vector from cage face marked φ

The angle θ can be measured by aligning the phase angle φ on the top face to the nearest multiple of 90°, then reading the angle of the vector from one of the cage's side faces marked θ

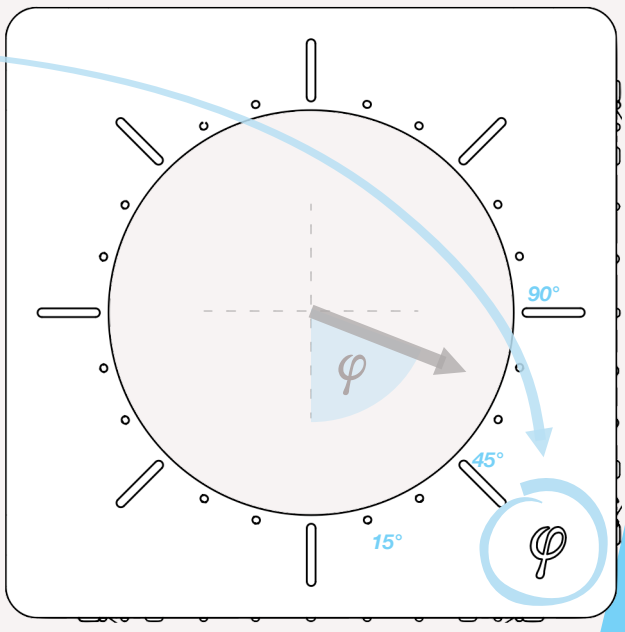
TOP FACE



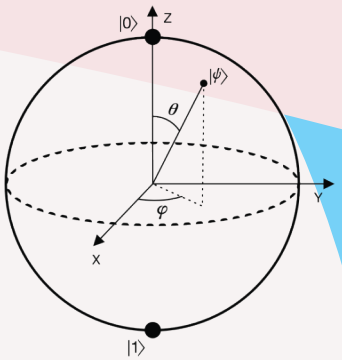
SIDE FACE



TOP FACE

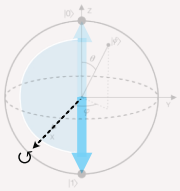
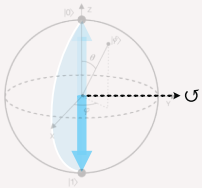
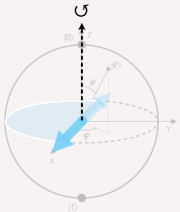
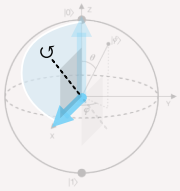
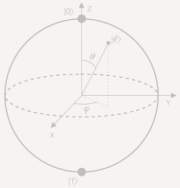


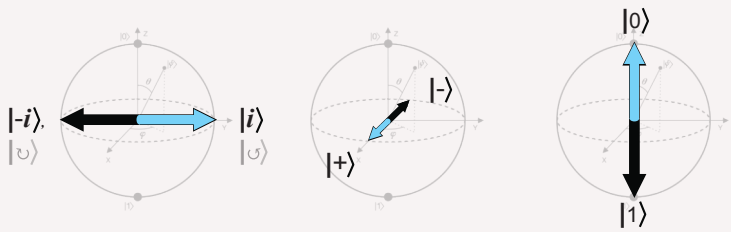
SINGLE-QUBIT GATES



Gates are computation operations.
The following is a list of single-qubit gates that will work with the abacus assembly, aside their geometric representations.

(Positive rotations are counter-clockwise ↺ about the

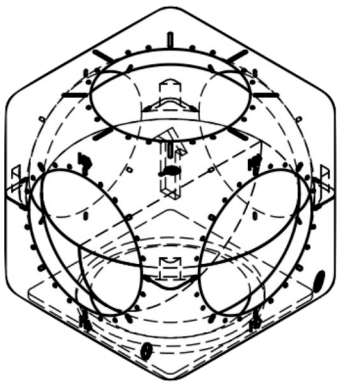
GATE	USE / A.K.A.	ROTATION	
X	Bit-Flip, NOT	Rotation by π radians around the X-AXIS of the Bloch sphere *SPECIAL CASE: Rx(ϕ) = rotation by ϕ radians around the X-AXIS of the Bloch sphere*	
Y	—	Rotation by π radians around the Y-AXIS of the Bloch sphere *SPECIAL CASE: Ry(ϕ) = rotation by ϕ radians around the Y-AXIS of the Bloch sphere*	
Z	Phase	Rotation by π radians around the Z-AXIS of the Bloch sphere *SPECIAL CASE: Rz(ϕ), P(ϕ) = rotation by ϕ radians around the Z-AXIS* *S, T = Rz(ϕ) where ϕ = π/2, π/4 respectively (TT = S, SS = Z)*	
H	Superposition	Rotation by π radians about the line X = Z, Y = 0 or vector [1,0,1] (simultaneous rotation π/2 about X, Z-AXES) *NOTE: H|0⟩ = |+⟩, H|1⟩ = |−⟩*	
I	Identity, Do-Nothing, None	No rotation	

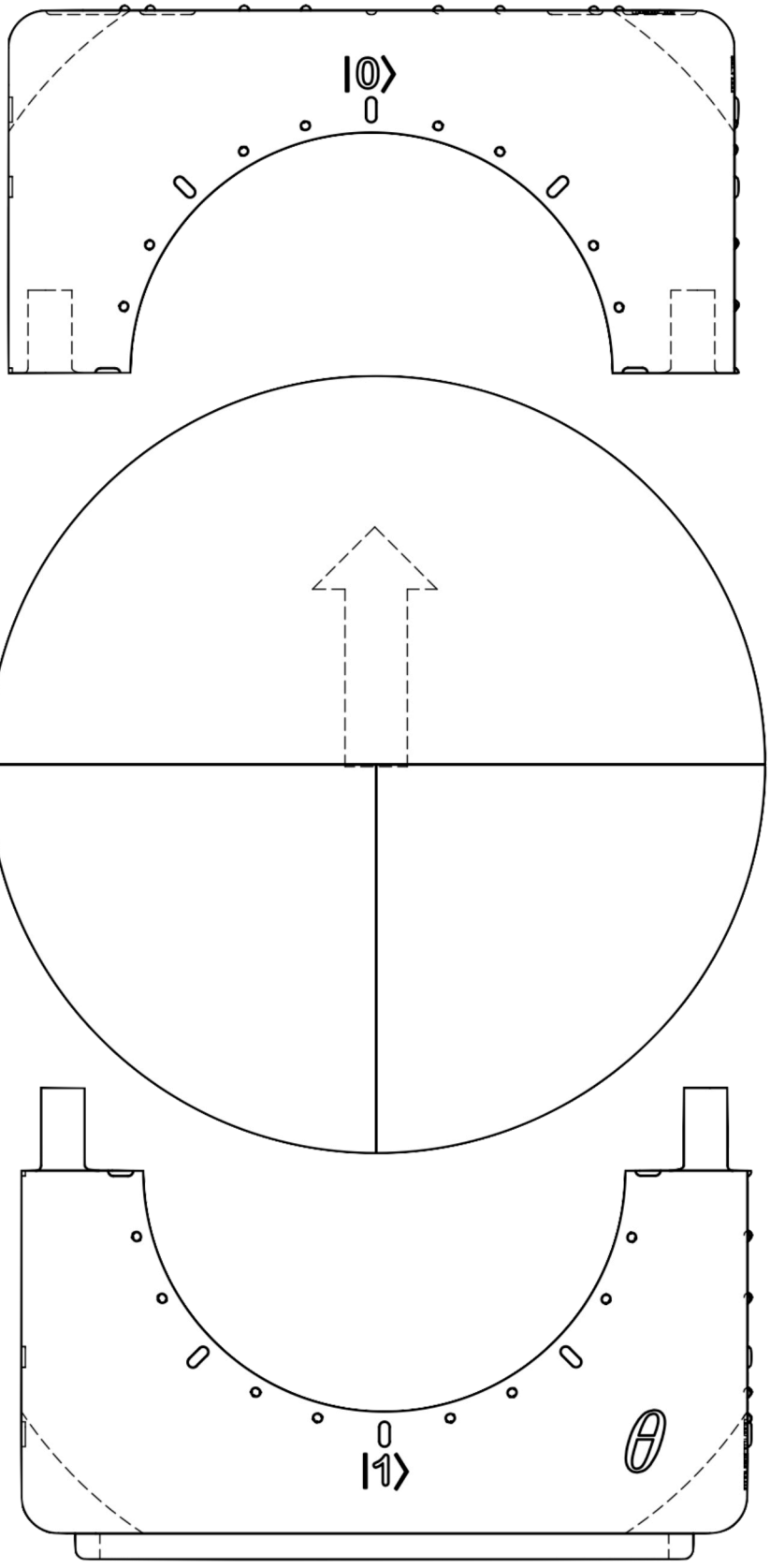


GATE IDENTITIES

Try out these identities to visualize different gates!

X = HZH	I = HH = XX = YY	Y = XS
Z = HXH	I = SSSS = ZZ	XH = HZ
S = YSX	Z = SS = TTTT	





QUBIT ASSEMBLY	
Drawing	1 of 1