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import numpy as np
import matplotlib.pyplot as plt

print("\n" + "="*50)
print("TASK 1: BORN RULE - MEASUREMENT PROBABILITIES")
print("="*50)

def born_rule_probabilities(psi):
    """Calculate measurement probabilities using Born rule:  $P = |\langle \text{basis} | \psi \rangle|^2$ """
    probabilities = np.abs(psi)**2
    return probabilities / np.sum(probabilities) # Normalize

# Create superposition states
psi_1 = np.array([1/np.sqrt(2), 1/np.sqrt(2)]) #  $|+\rangle$  state
psi_2 = np.array([1/np.sqrt(3), np.sqrt(2/3)]) # Custom superposition

print("Superposition state 1:  $|\psi_1\rangle =$ ", psi_1)
print("Measurement probabilities:",
      born_rule_probabilities(psi_1))
print("Superposition state 2:  $|\psi_2\rangle =$ ", psi_2)
print("Measurement probabilities:",
      born_rule_probabilities(psi_2))

# Visualization
states = [' $|0\rangle$ ', ' $|1\rangle$ ']
probs_1 = born_rule_probabilities(psi_1)

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probs_2 = born_rule_probabilities(psi_2)
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plt.figure(figsize=(10, 4))
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plt.subplot(1, 2, 1)
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plt.bar(states, probs_1, color='blue', alpha=0.7)
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plt.title('State  $|\psi_1\rangle$  Probabilities')
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plt.ylabel('Probability')
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```
plt.subplot(1, 2, 2)
```

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plt.bar(states, probs_2, color='red', alpha=0.7)
```

```
plt.title('State  $|\psi_2\rangle$  Probabilities')
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```
plt.ylabel('Probability')
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plt.tight_layout()
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plt.show()
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