

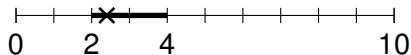
Bertrand's paradox

Márton Balázs

University of Bristol

Uniform distribution

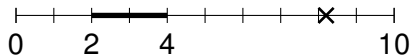
Pick a random point that's *equally likely to be anywhere* on $[0, 10]$.



$$\mathbb{P}\{\text{---}\} = ?$$

Uniform distribution

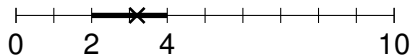
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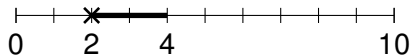
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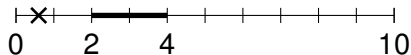
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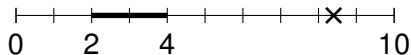
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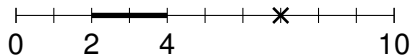
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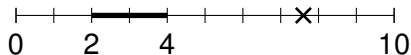
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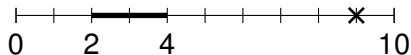
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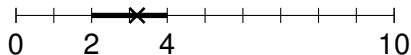
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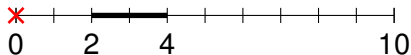
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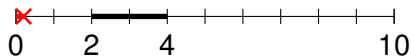
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$$\mathbb{P}\{\text{thick bar}\} = ?$$

Uniform distribution

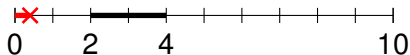
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Uniform distribution

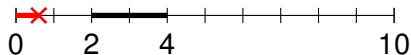
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Uniform distribution

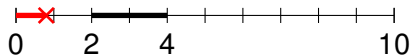
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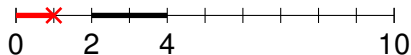
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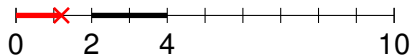
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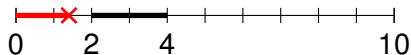
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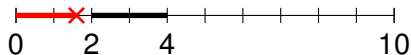
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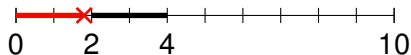
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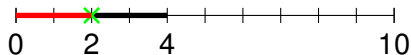
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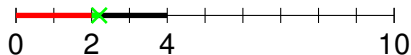
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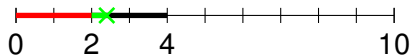
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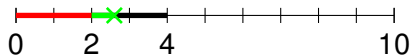
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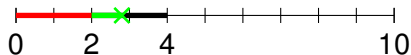
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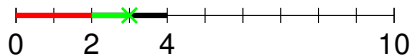
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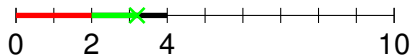
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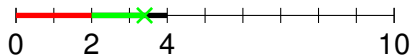
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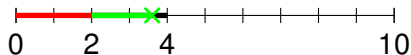
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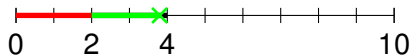
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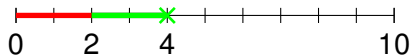
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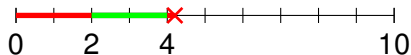
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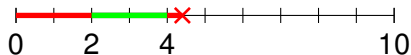
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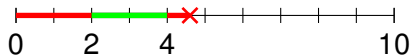
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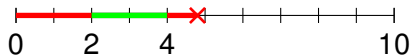
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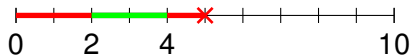
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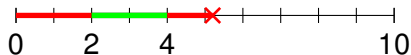
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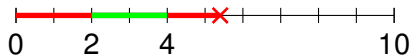
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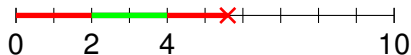
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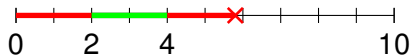
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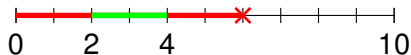
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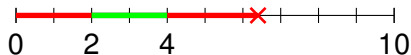
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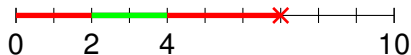
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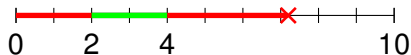
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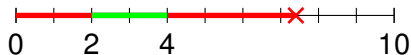
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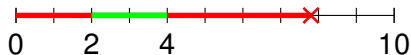
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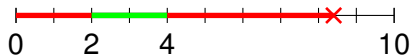
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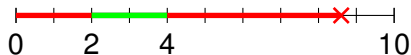
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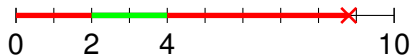
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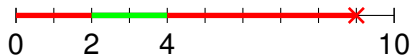
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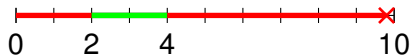
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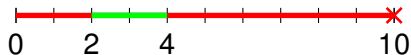
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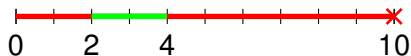
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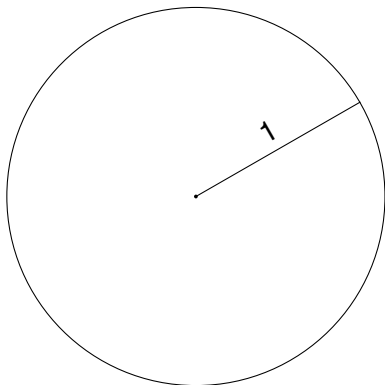
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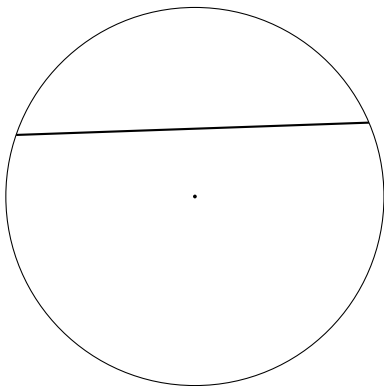


$$\mathbb{P}\{\text{---}\} = \frac{|\text{---}|}{|\text{---}|} = \frac{2}{10} = \frac{1}{5}.$$

Random chords and a question

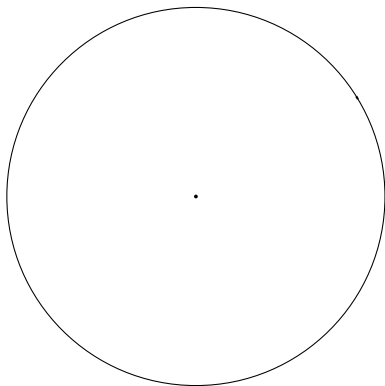


Random chords and a question



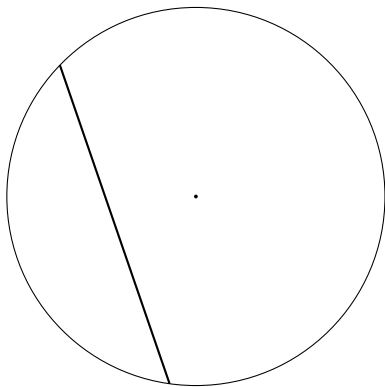
random chord

Random chords and a question



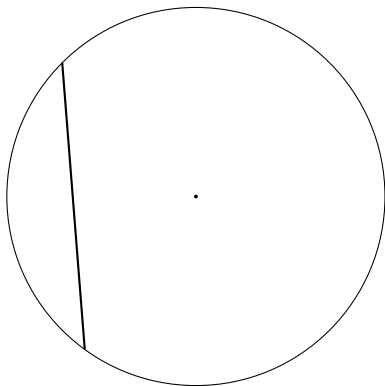
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Random chords and a question



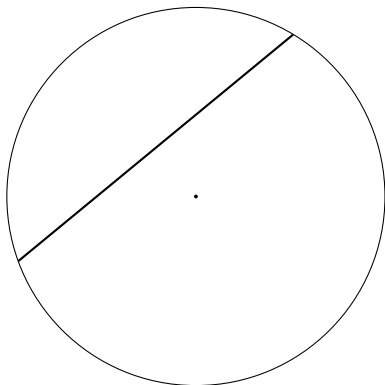
random chord

Random chords and a question



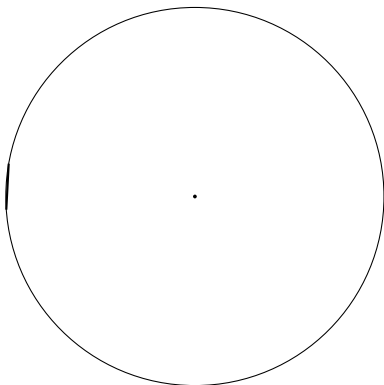
random chord

Random chords and a question



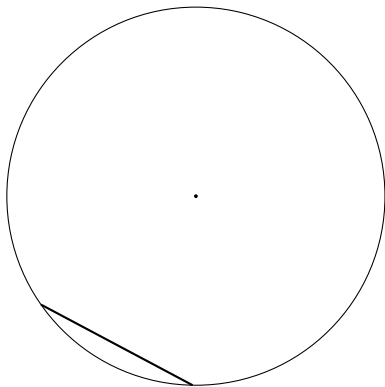
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Random chords and a question



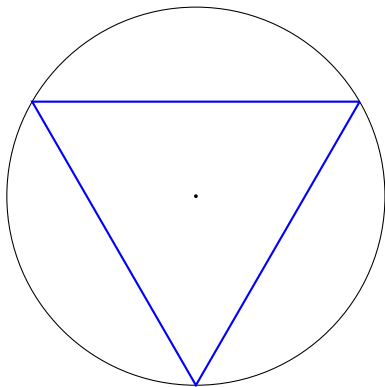
random chord

Random chords and a question



random chord

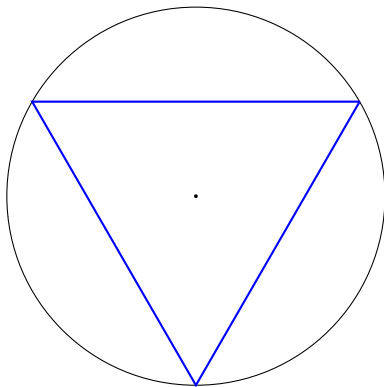
Random chords and a question



random chord

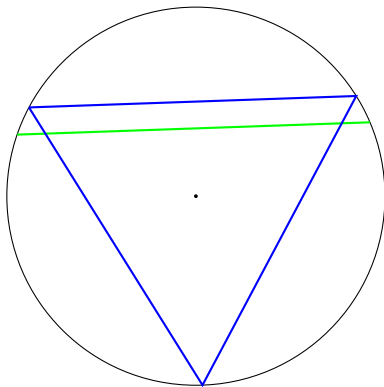


Random chords and a question



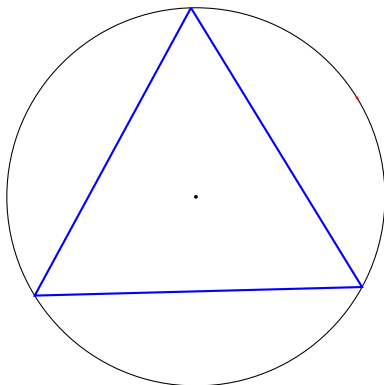
$\mathbb{P}\{\text{random chord is longer than one side of the } \nabla\}$?

Random chords and a question



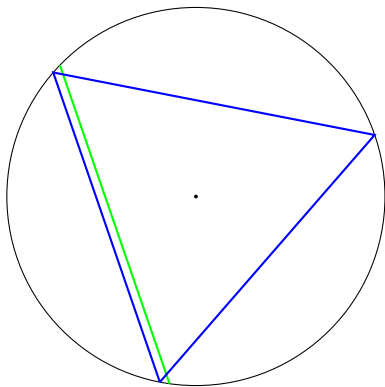
$\mathbb{P}\{\text{random chord is longer than one side of the } \triangle\}$?

Random chords and a question



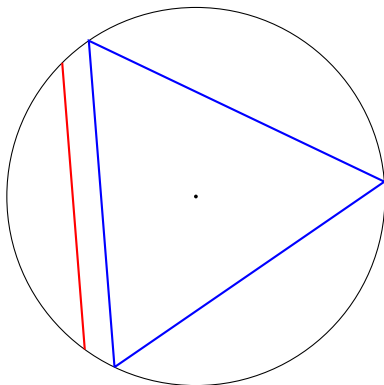
$\mathbb{P}\{\text{random chord is longer than one side of the } \triangle\}$?

Random chords and a question



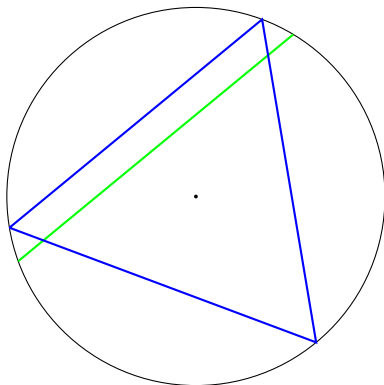
$\mathbb{P}\{\text{random chord is longer than one side of the } \triangle\}$?

Random chords and a question



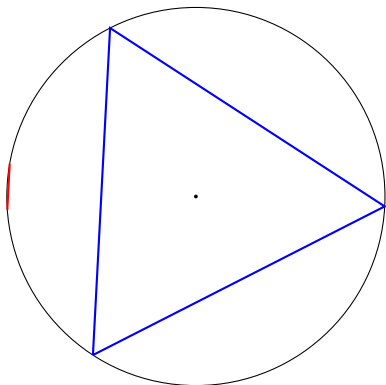
$\mathbb{P}\{\text{random chord is longer than one side of the } \triangle\}$?

Random chords and a question



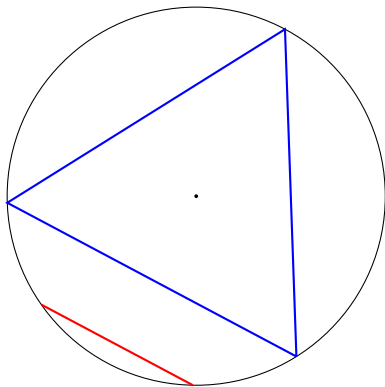
$\mathbb{P}\{\text{random chord is longer than one side of the } \triangle\}$?

Random chords and a question



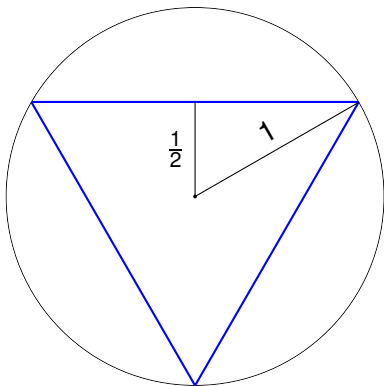
$\mathbb{P}\{\text{random chord is longer than one side of the } \triangle\}$?

Random chords and a question

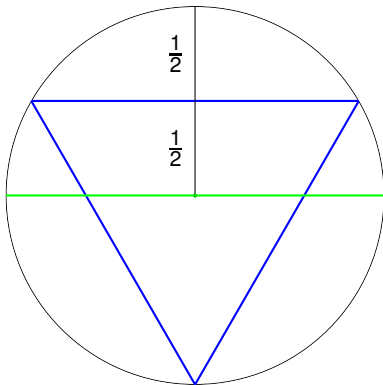


$\mathbb{P}\{\text{random chord is longer than one side of the } \triangle\}$?

Answer: $\frac{1}{2}$

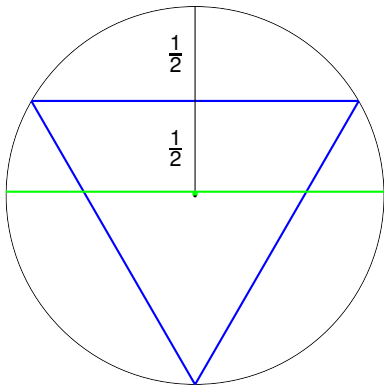


Answer: $\frac{1}{2}$



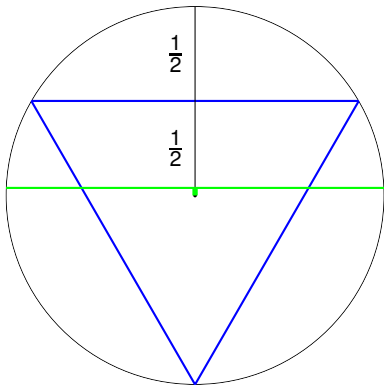
Distance from center:

Answer: $\frac{1}{2}$



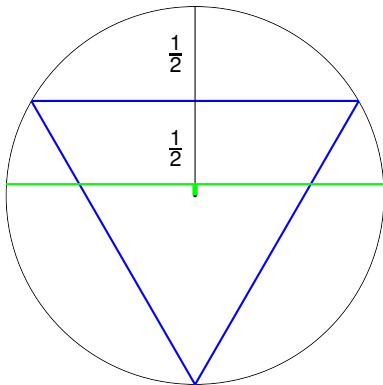
Distance from center:

Answer: $\frac{1}{2}$



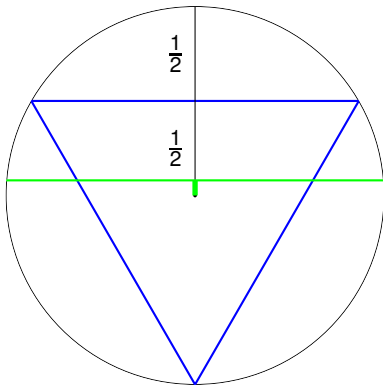
Distance from center:

Answer: $\frac{1}{2}$



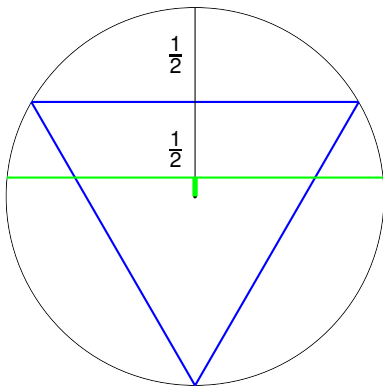
Distance from center:

Answer: $\frac{1}{2}$



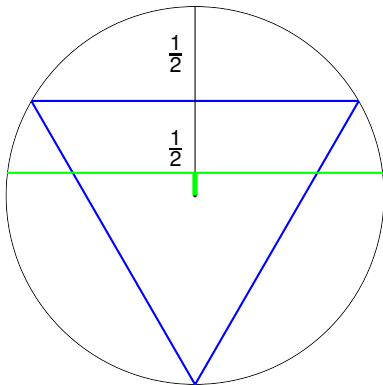
Distance from center:

Answer: $\frac{1}{2}$



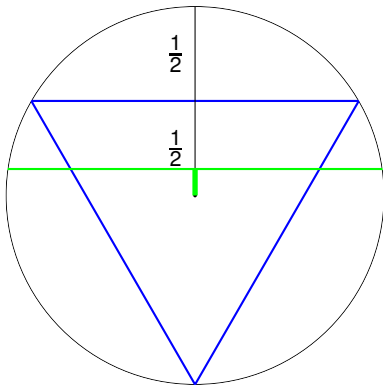
Distance from center:

Answer: $\frac{1}{2}$



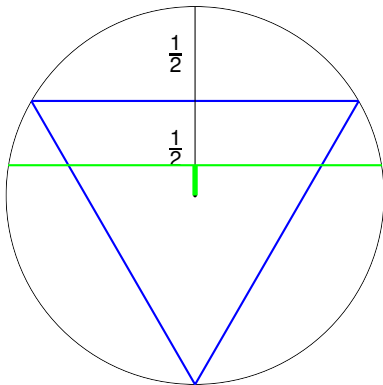
Distance from center:

Answer: $\frac{1}{2}$



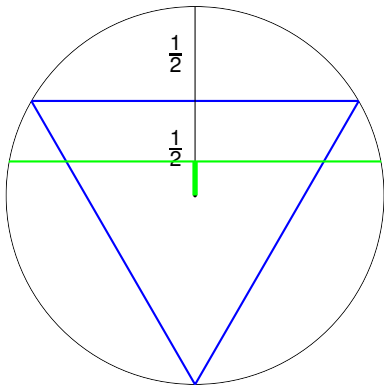
Distance from center:

Answer: $\frac{1}{2}$



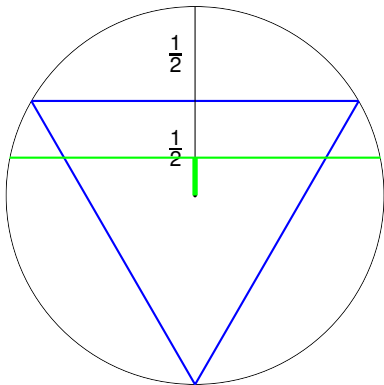
Distance from center:

Answer: $\frac{1}{2}$



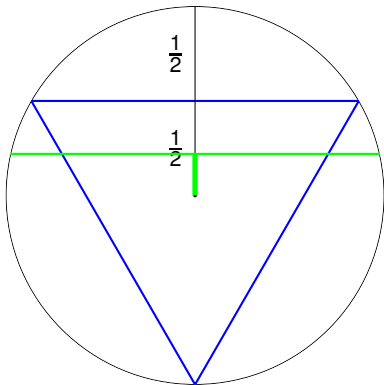
Distance from center:

Answer: $\frac{1}{2}$



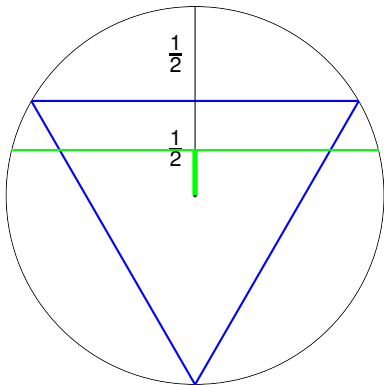
Distance from center:

Answer: $\frac{1}{2}$



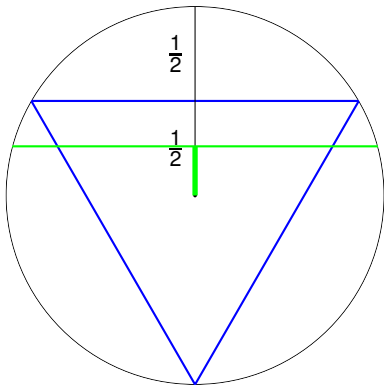
Distance from center:

Answer: $\frac{1}{2}$



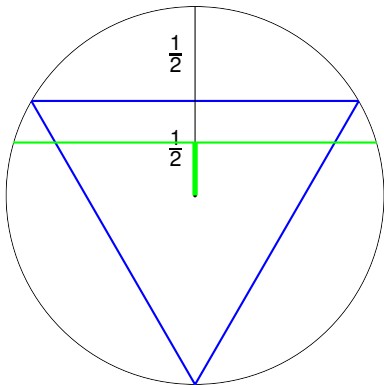
Distance from center:

Answer: $\frac{1}{2}$



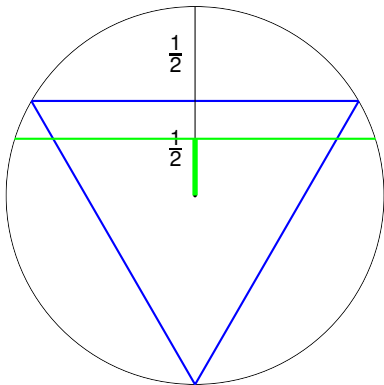
Distance from center:

Answer: $\frac{1}{2}$



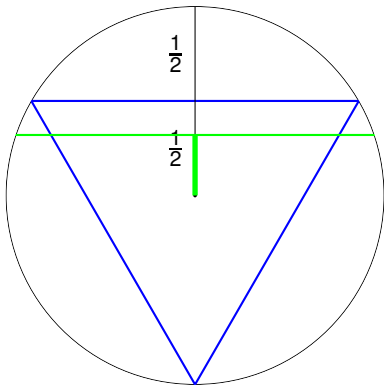
Distance from center:

Answer: $\frac{1}{2}$



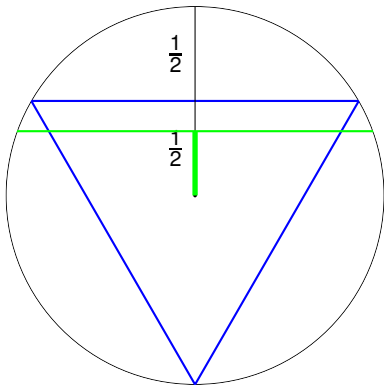
Distance from center:

Answer: $\frac{1}{2}$



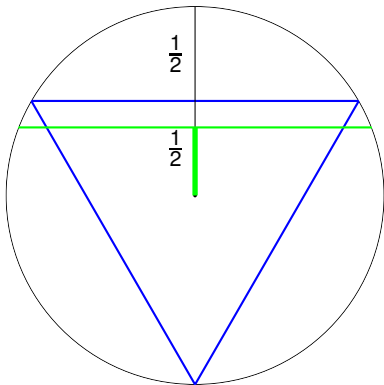
Distance from center:

Answer: $\frac{1}{2}$



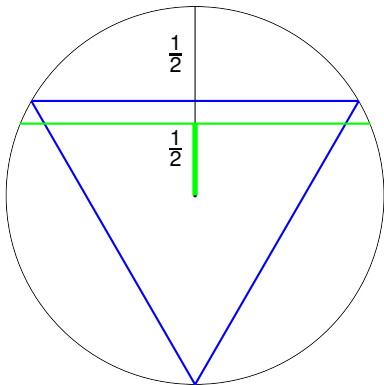
Distance from center:

Answer: $\frac{1}{2}$



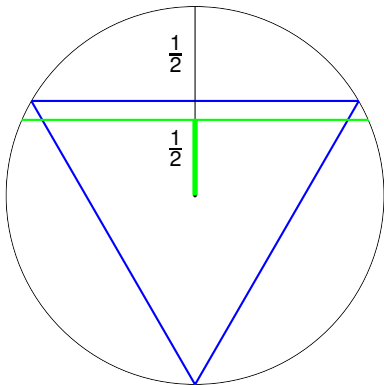
Distance from center:

Answer: $\frac{1}{2}$



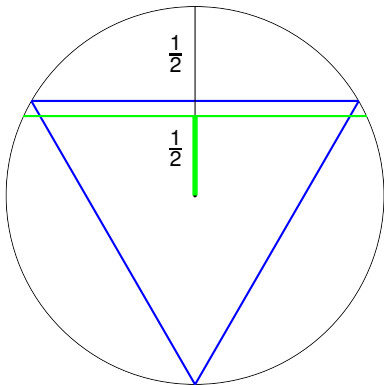
Distance from center:

Answer: $\frac{1}{2}$



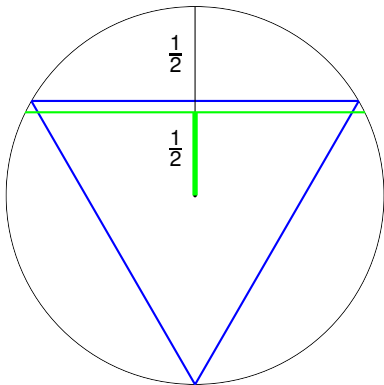
Distance from center:

Answer: $\frac{1}{2}$



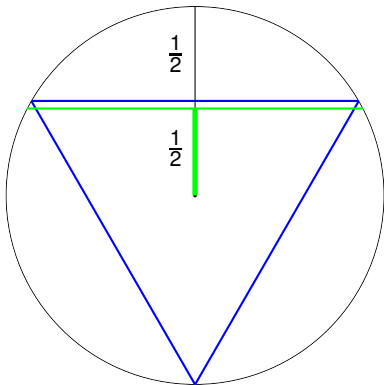
Distance from center:

Answer: $\frac{1}{2}$



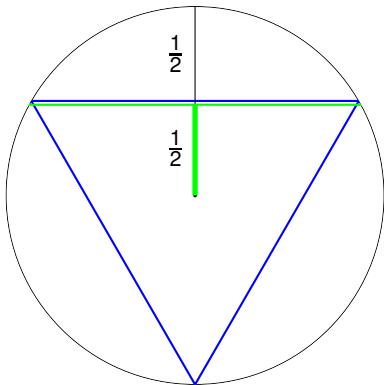
Distance from center:

Answer: $\frac{1}{2}$



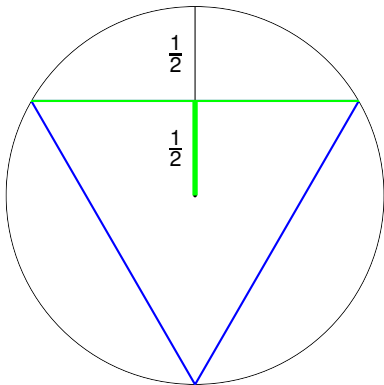
Distance from center:

Answer: $\frac{1}{2}$



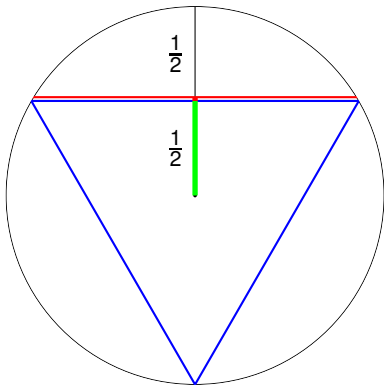
Distance from center:

Answer: $\frac{1}{2}$



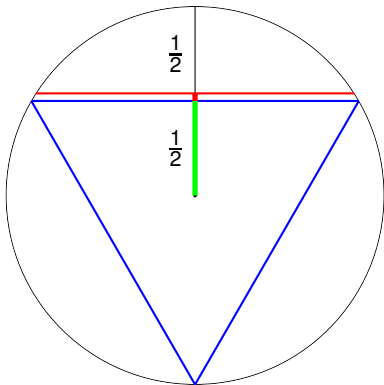
Distance from center:

Answer: $\frac{1}{2}$



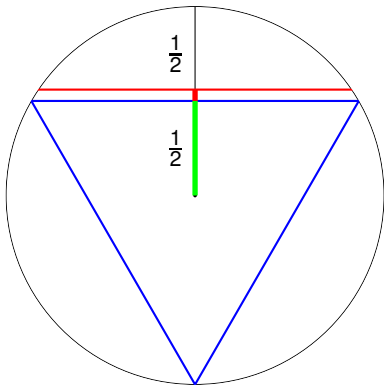
Distance from center:

Answer: $\frac{1}{2}$



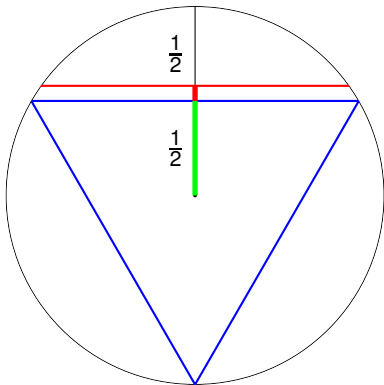
Distance from center:

Answer: $\frac{1}{2}$



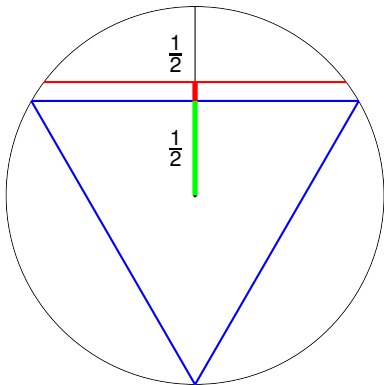
Distance from center:

Answer: $\frac{1}{2}$



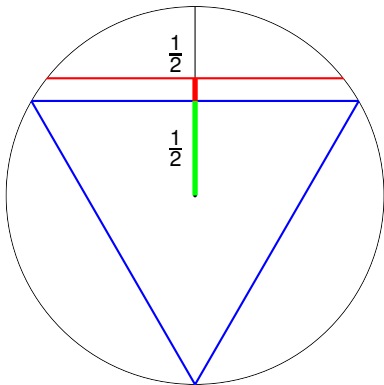
Distance from center:

Answer: $\frac{1}{2}$



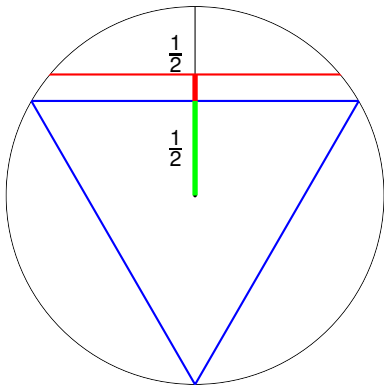
Distance from center:

Answer: $\frac{1}{2}$



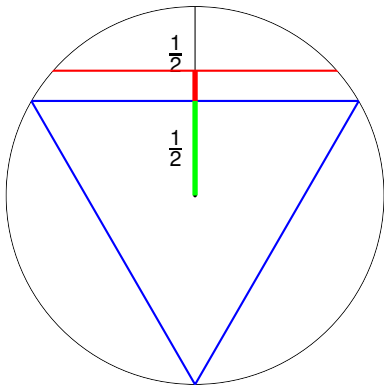
Distance from center:

Answer: $\frac{1}{2}$



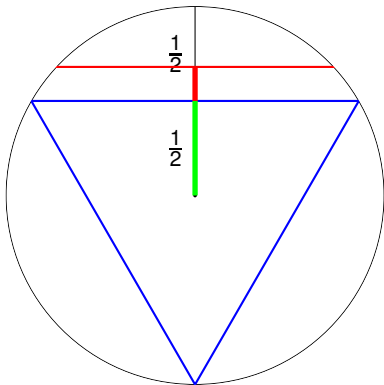
Distance from center:

Answer: $\frac{1}{2}$



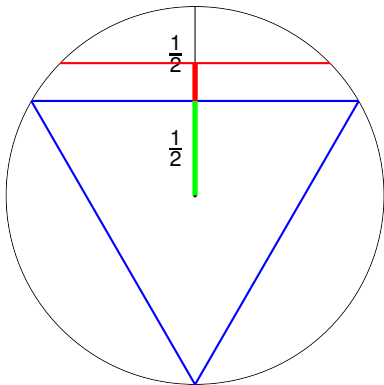
Distance from center:

Answer: $\frac{1}{2}$



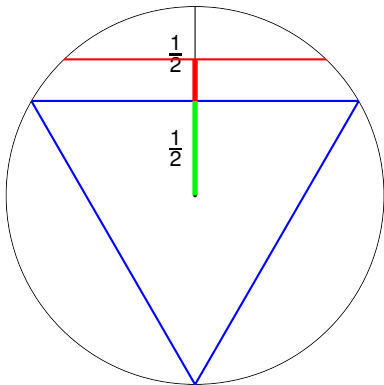
Distance from center:

Answer: $\frac{1}{2}$



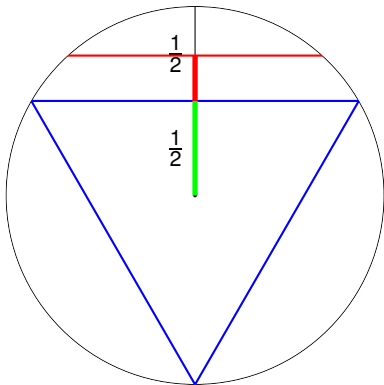
Distance from center:

Answer: $\frac{1}{2}$



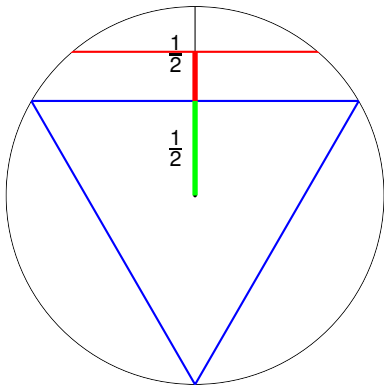
Distance from center:

Answer: $\frac{1}{2}$



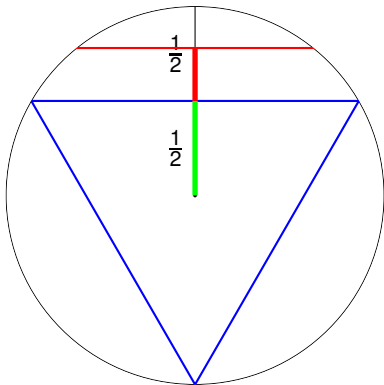
Distance from center:

Answer: $\frac{1}{2}$



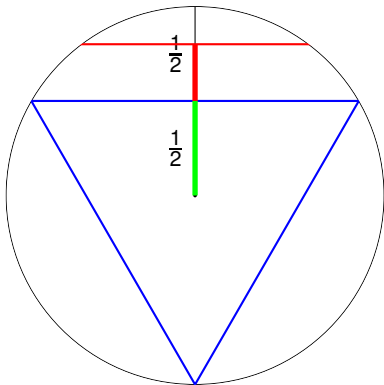
Distance from center:

Answer: $\frac{1}{2}$



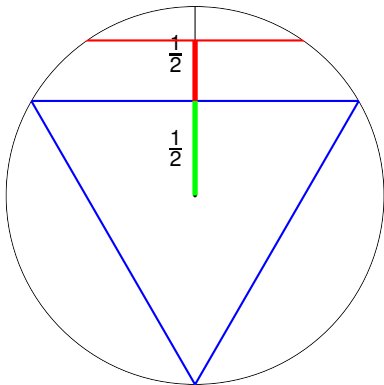
Distance from center:

Answer: $\frac{1}{2}$



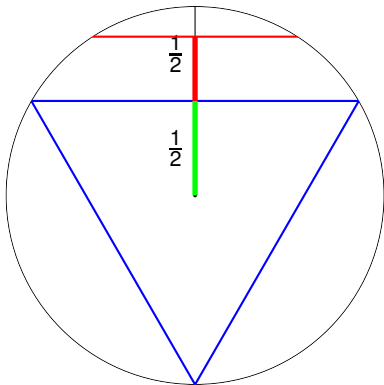
Distance from center:

Answer: $\frac{1}{2}$



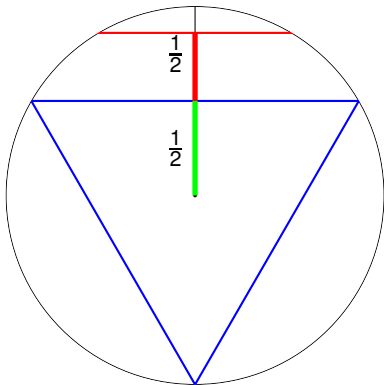
Distance from center:

Answer: $\frac{1}{2}$



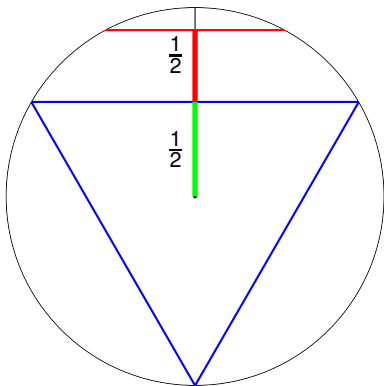
Distance from center:

Answer: $\frac{1}{2}$



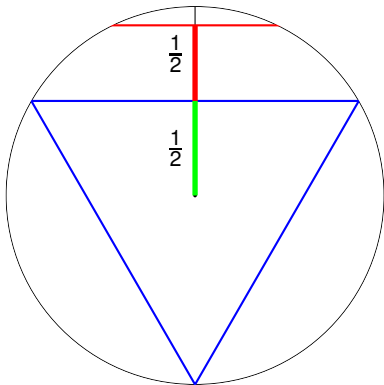
Distance from center:

Answer: $\frac{1}{2}$



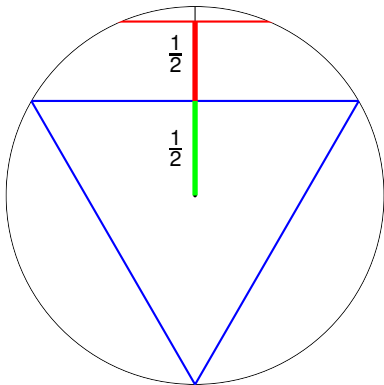
Distance from center:

Answer: $\frac{1}{2}$



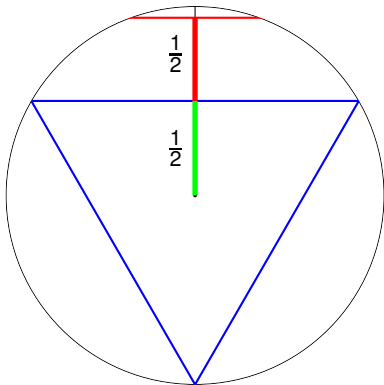
Distance from center:

Answer: $\frac{1}{2}$



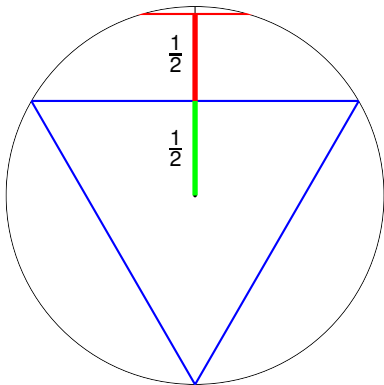
Distance from center:

Answer: $\frac{1}{2}$



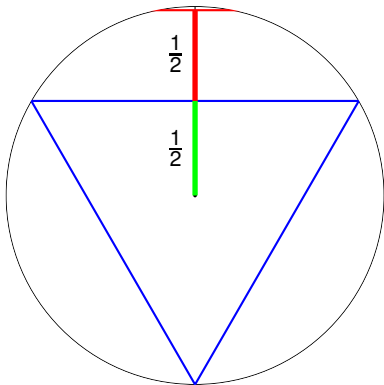
Distance from center:

Answer: $\frac{1}{2}$



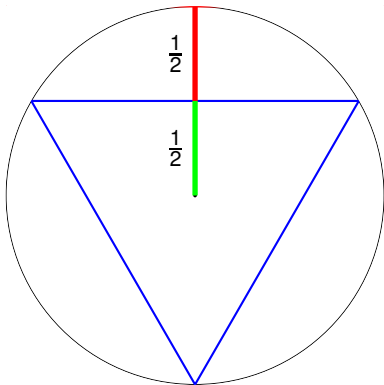
Distance from center:

Answer: $\frac{1}{2}$



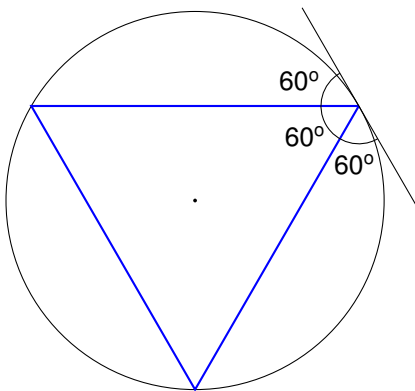
Distance from center:

Answer: $\frac{1}{2}$

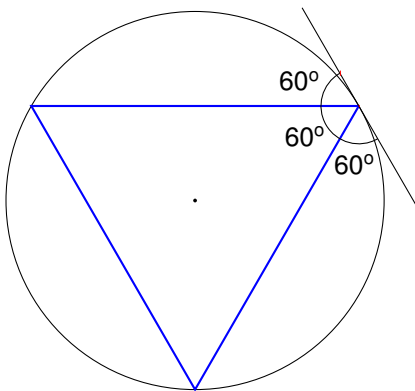


Distance from center: $\frac{\frac{1}{2}}{\frac{1}{2} + \frac{1}{2}} = \frac{1}{2}$.

Wait... it's $\frac{1}{3}$!

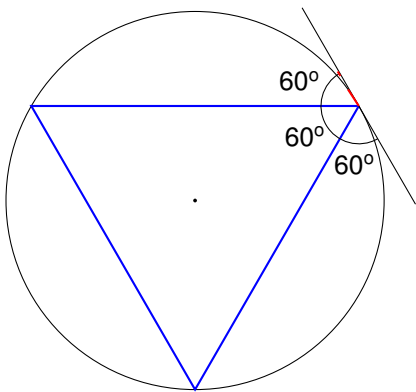


Wait... it's $\frac{1}{3}$!



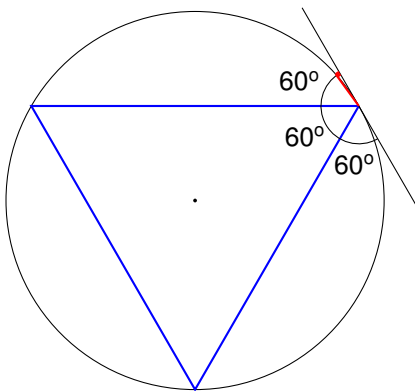
Angle:

Wait... it's $\frac{1}{3}$!



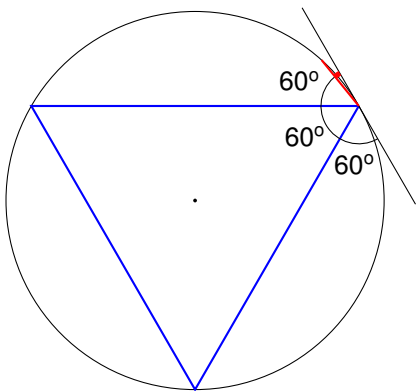
Angle:

Wait... it's $\frac{1}{3}$!



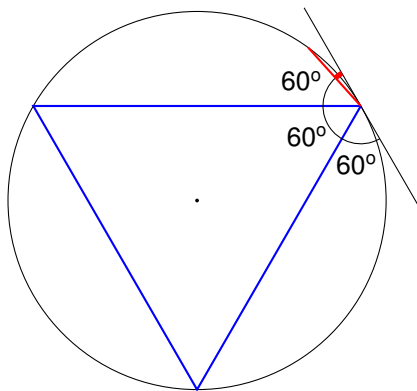
Angle:

Wait... it's $\frac{1}{3}$!



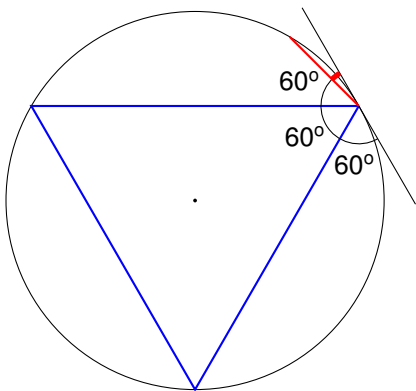
Angle:

Wait... it's $\frac{1}{3}$!



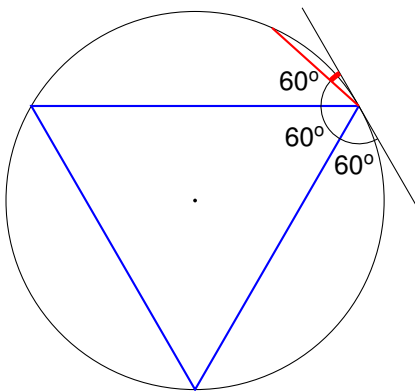
Angle:

Wait... it's $\frac{1}{3}$!



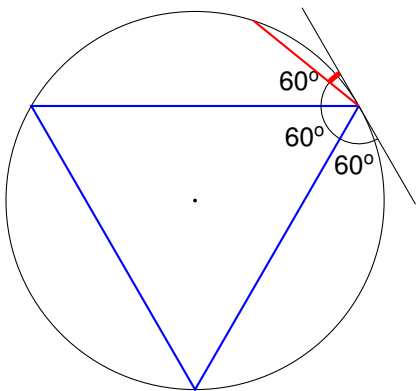
Angle:

Wait... it's $\frac{1}{3}$!



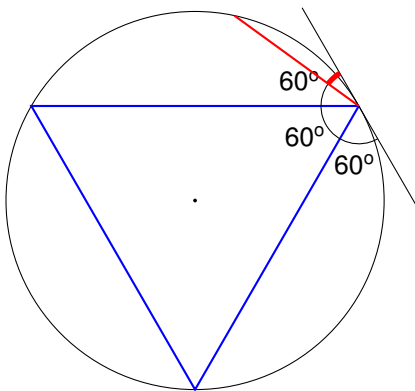
Angle:

Wait... it's $\frac{1}{3}$!



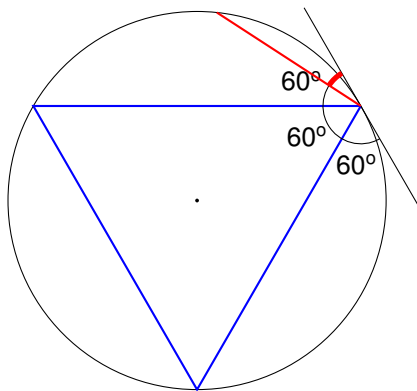
Angle:

Wait... it's $\frac{1}{3}$!



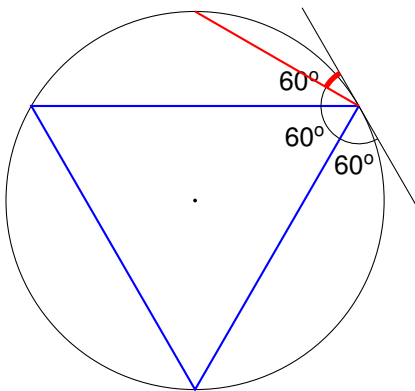
Angle:

Wait... it's $\frac{1}{3}$!



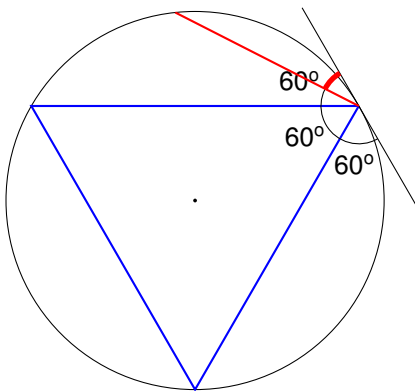
Angle:

Wait... it's $\frac{1}{3}$!



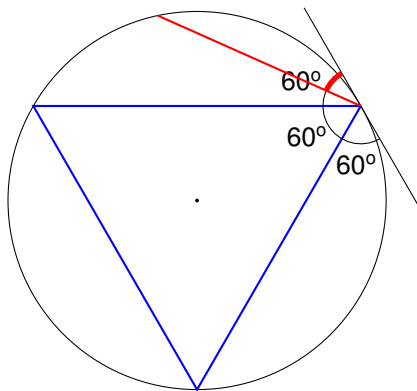
Angle:

Wait... it's $\frac{1}{3}$!



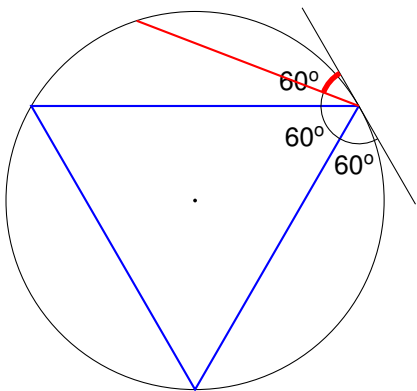
Angle:

Wait... it's $\frac{1}{3}$!



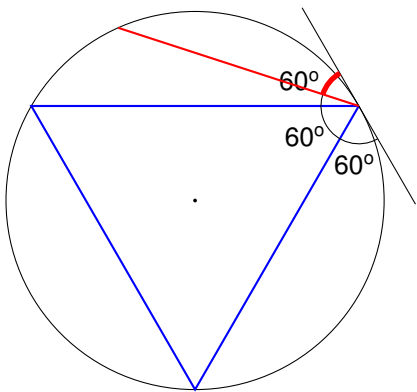
Angle:

Wait... it's $\frac{1}{3}$!



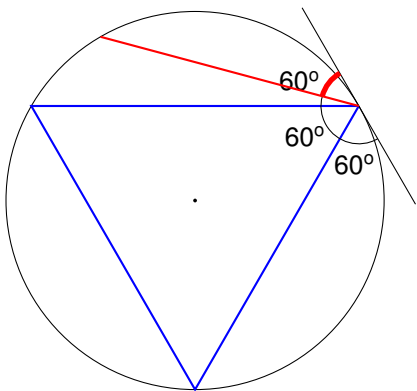
Angle:

Wait... it's $\frac{1}{3}$!



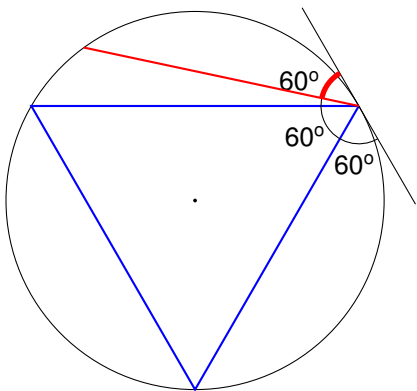
Angle:

Wait... it's $\frac{1}{3}$!



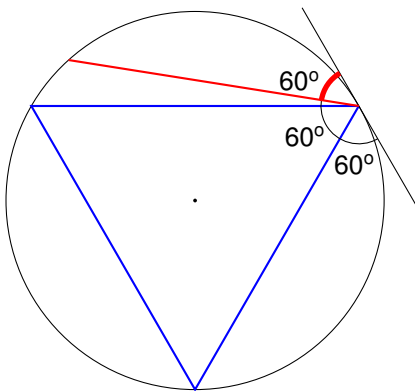
Angle:

Wait... it's $\frac{1}{3}$!



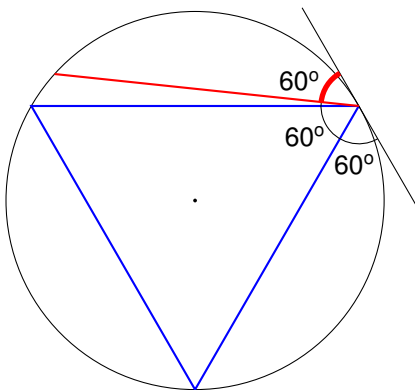
Angle:

Wait... it's $\frac{1}{3}$!



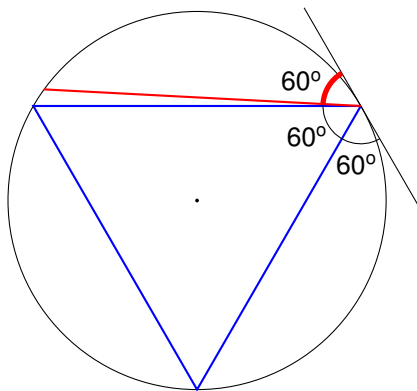
Angle:

Wait... it's $\frac{1}{3}$!



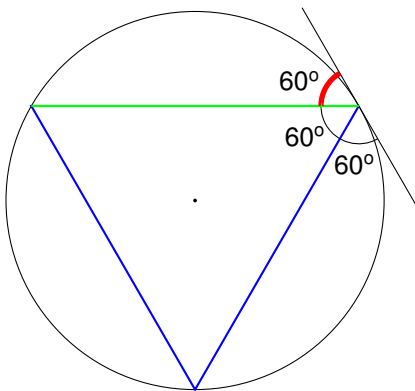
Angle:

Wait... it's $\frac{1}{3}$!



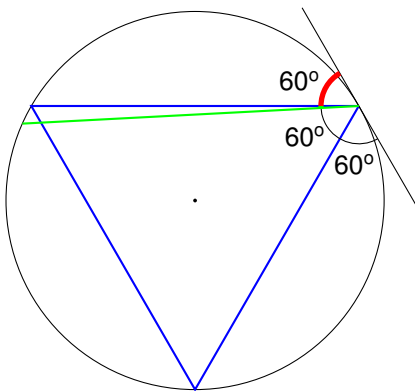
Angle:

Wait... it's $\frac{1}{3}$!



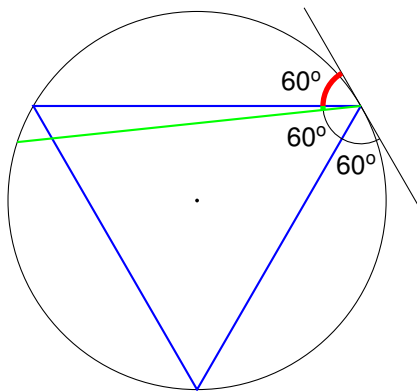
Angle:

Wait... it's $\frac{1}{3}$!



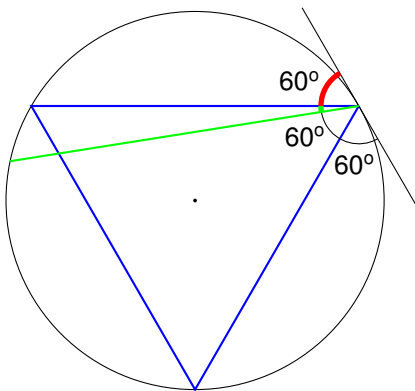
Angle:

Wait... it's $\frac{1}{3}$!



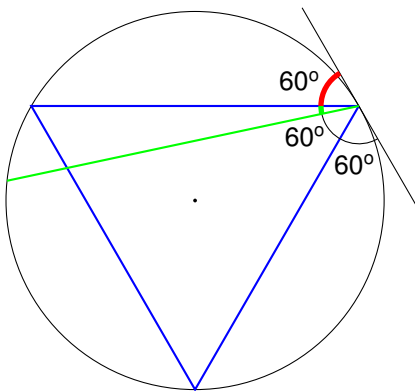
Angle:

Wait... it's $\frac{1}{3}$!



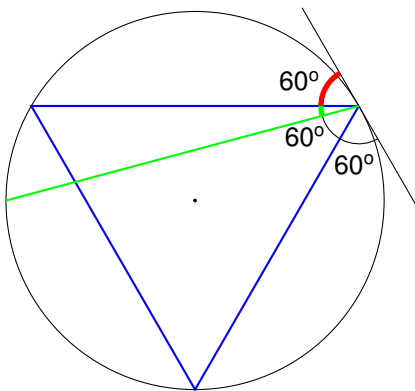
Angle:

Wait... it's $\frac{1}{3}$!



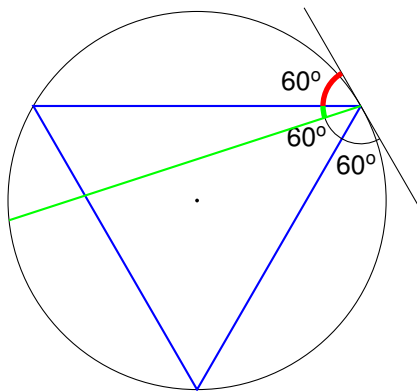
Angle:

Wait... it's $\frac{1}{3}$!



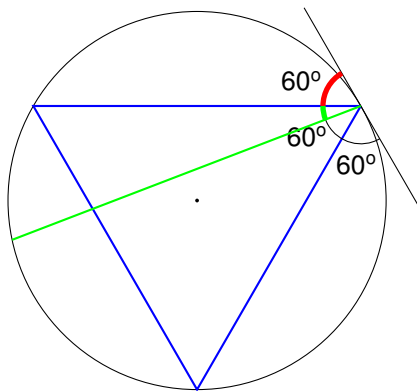
Angle:

Wait... it's $\frac{1}{3}$!



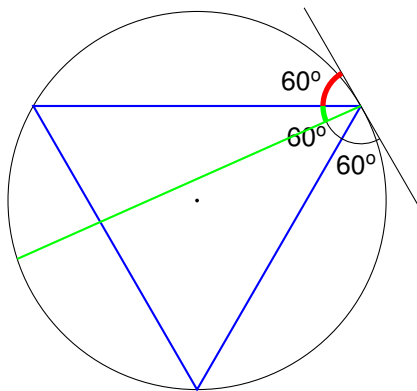
Angle:

Wait... it's $\frac{1}{3}$!



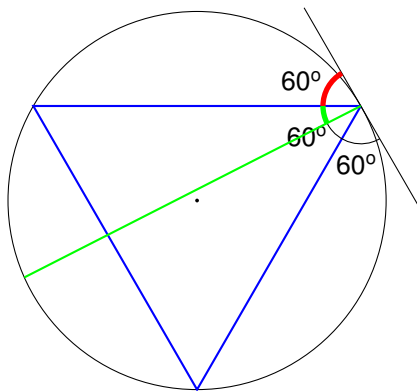
Angle:

Wait... it's $\frac{1}{3}$!



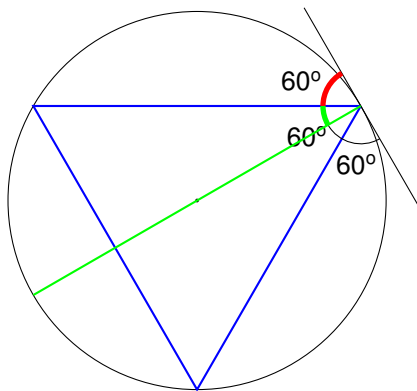
Angle:

Wait... it's $\frac{1}{3}$!



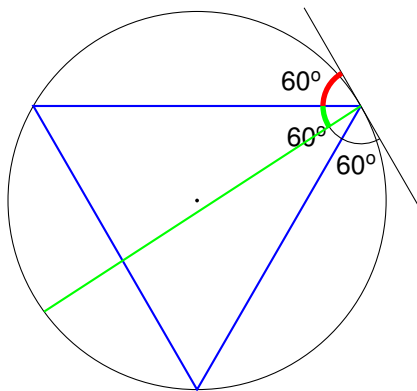
Angle:

Wait... it's $\frac{1}{3}$!



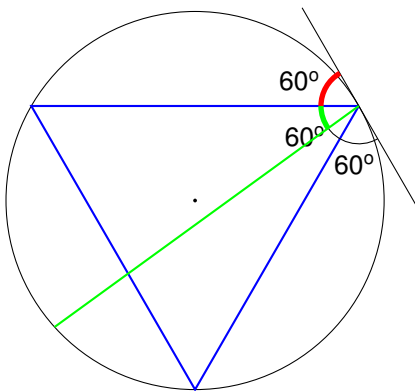
Angle:

Wait... it's $\frac{1}{3}$!



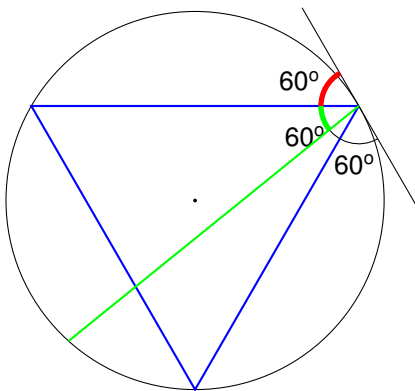
Angle:

Wait... it's $\frac{1}{3}$!



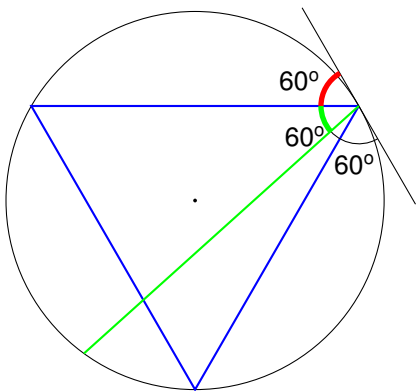
Angle:

Wait... it's $\frac{1}{3}$!



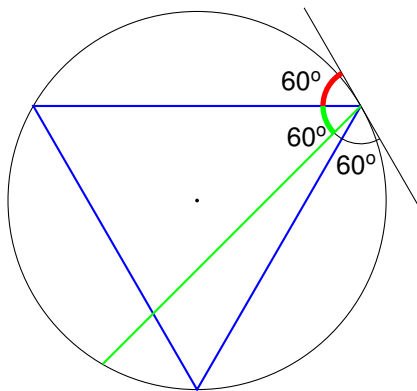
Angle:

Wait... it's $\frac{1}{3}$!



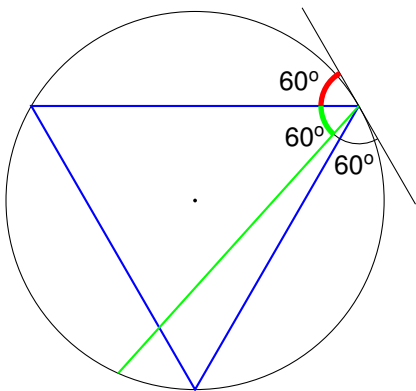
Angle:

Wait... it's $\frac{1}{3}$!



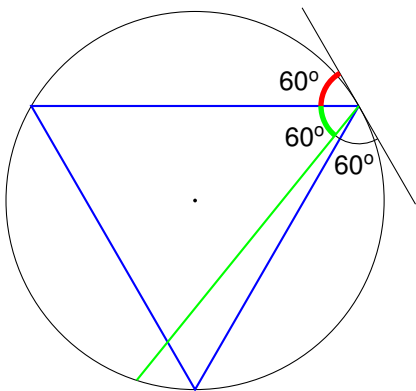
Angle:

Wait... it's $\frac{1}{3}$!



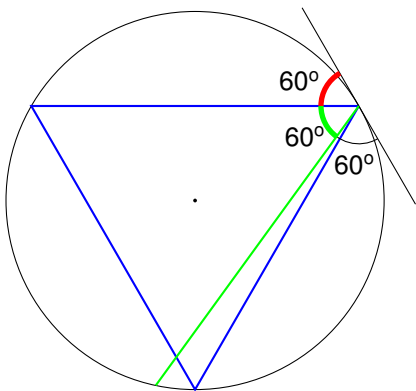
Angle:

Wait... it's $\frac{1}{3}$!



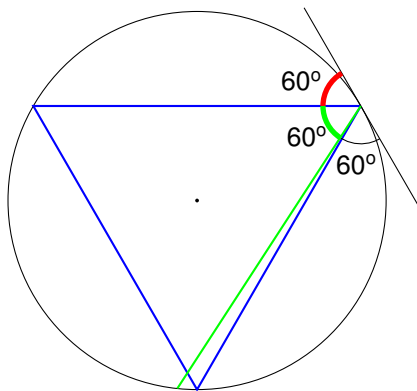
Angle:

Wait... it's $\frac{1}{3}$!



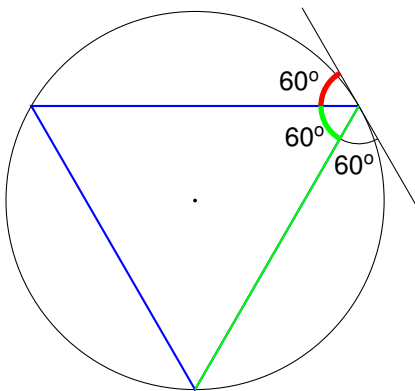
Angle:

Wait... it's $\frac{1}{3}$!



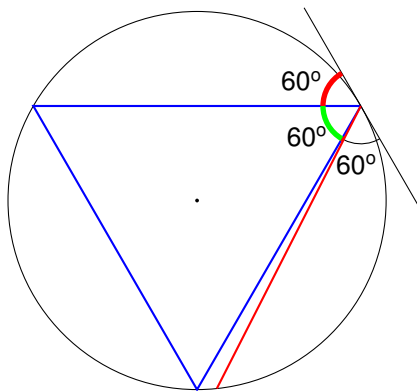
Angle:

Wait... it's $\frac{1}{3}$!



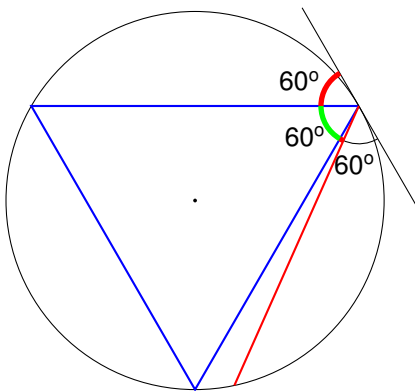
Angle:

Wait... it's $\frac{1}{3}$!



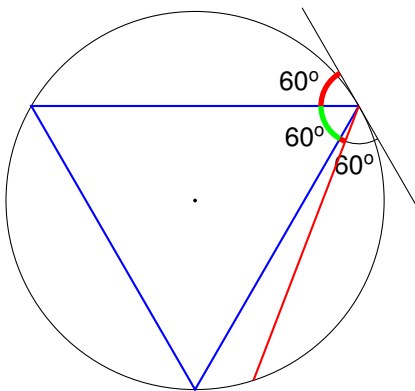
Angle:

Wait... it's $\frac{1}{3}$!



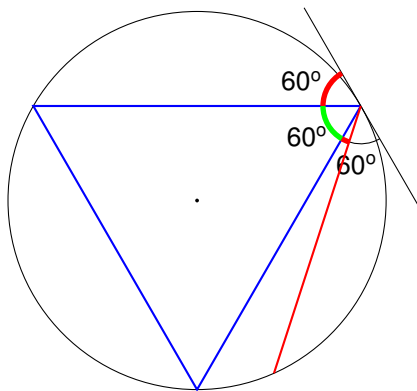
Angle:

Wait... it's $\frac{1}{3}$!



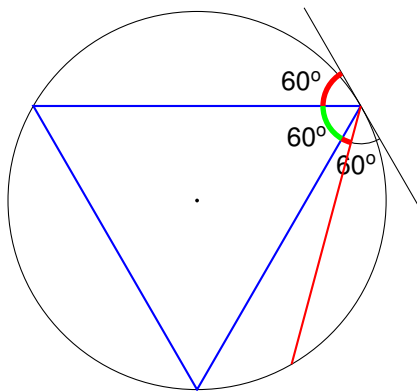
Angle:

Wait... it's $\frac{1}{3}$!



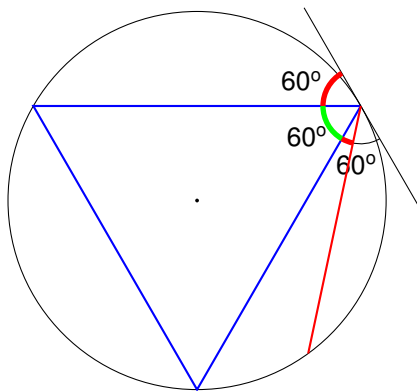
Angle:

Wait... it's $\frac{1}{3}$!



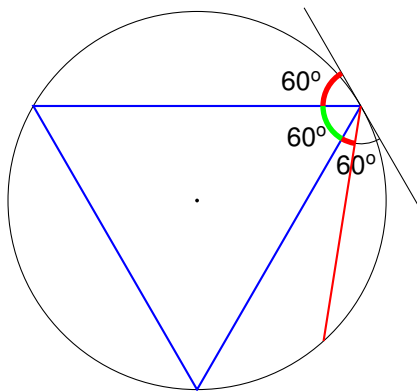
Angle:

Wait... it's $\frac{1}{3}$!



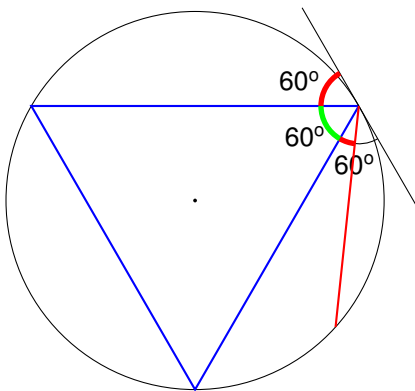
Angle:

Wait... it's $\frac{1}{3}$!



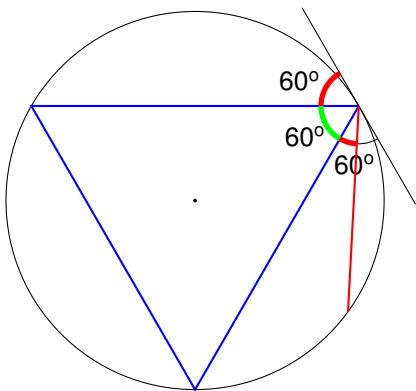
Angle:

Wait... it's $\frac{1}{3}$!



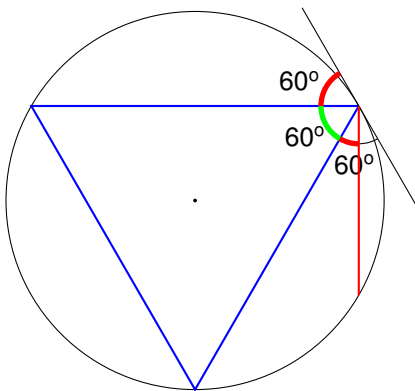
Angle:

Wait... it's $\frac{1}{3}$!



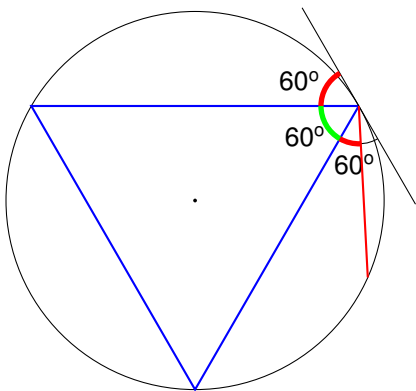
Angle:

Wait... it's $\frac{1}{3}$!



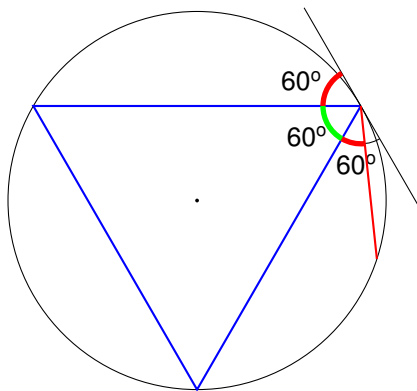
Angle:

Wait... it's $\frac{1}{3}$!



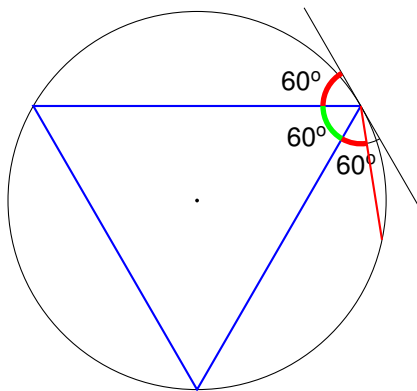
Angle:

Wait... it's $\frac{1}{3}$!



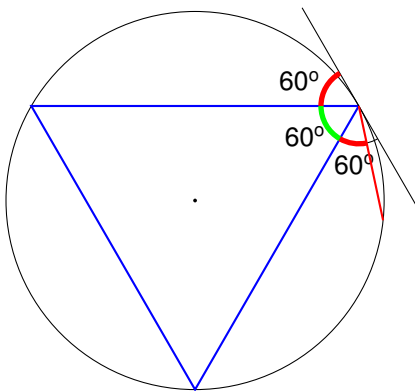
Angle:

Wait... it's $\frac{1}{3}$!



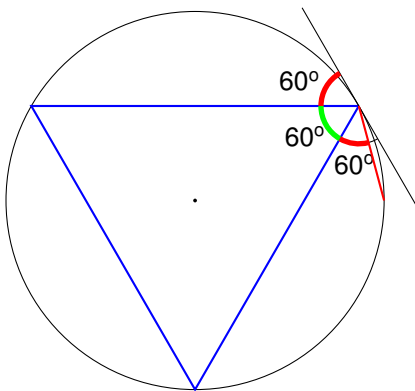
Angle:

Wait... it's $\frac{1}{3}$!



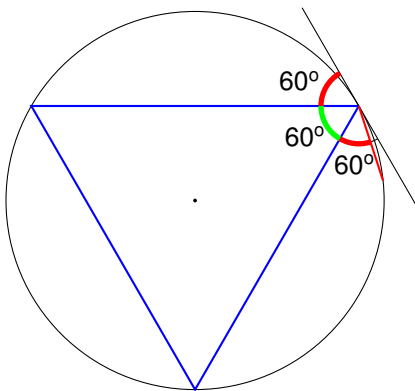
Angle:

Wait... it's $\frac{1}{3}$!



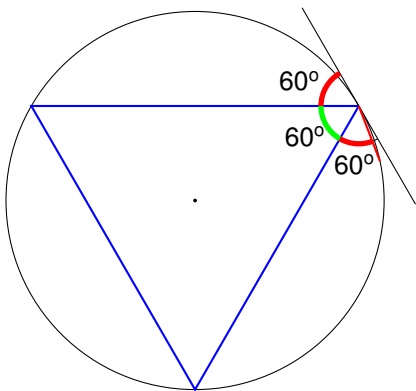
Angle:

Wait... it's $\frac{1}{3}$!



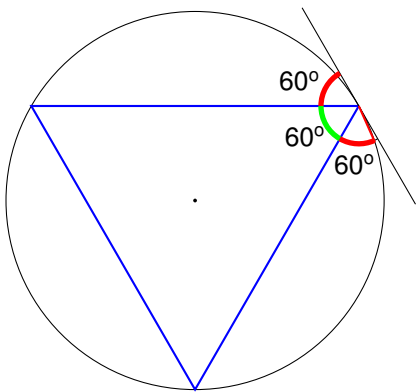
Angle:

Wait... it's $\frac{1}{3}$!



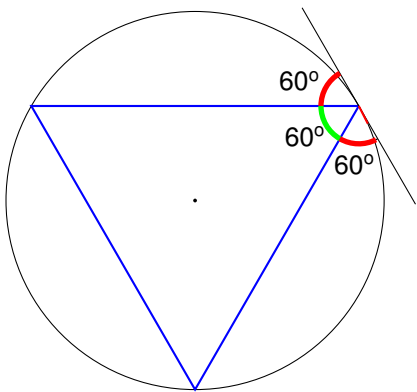
Angle:

Wait... it's $\frac{1}{3}$!



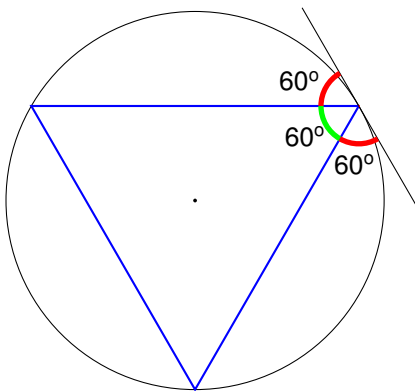
Angle:

Wait... it's $\frac{1}{3}$!



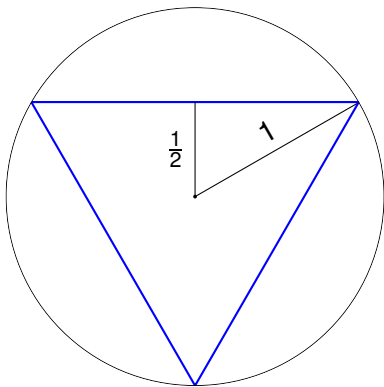
Angle:

Wait... it's $\frac{1}{3}$!

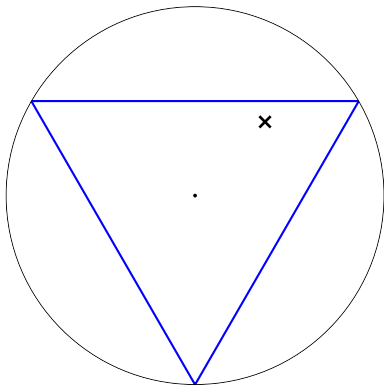


Angle: $\frac{60^\circ}{60^\circ + 60^\circ + 60^\circ} = \frac{1}{3}$.

Oh wait. . . it's $\frac{1}{4}$!

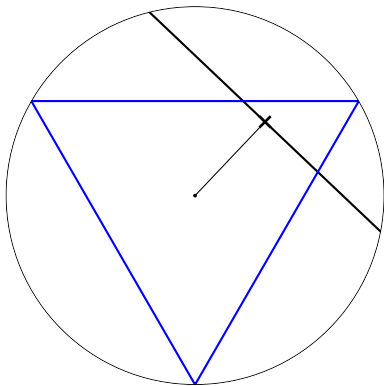


Oh wait. . . it's $\frac{1}{4}$!



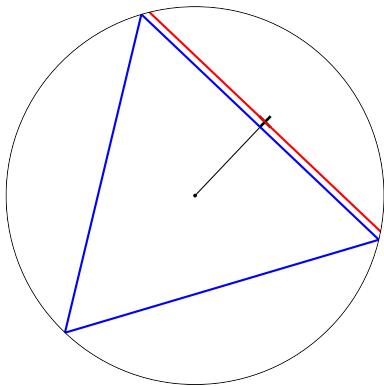
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



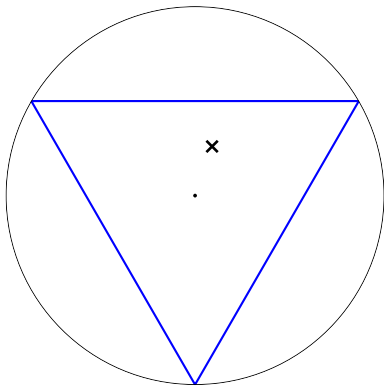
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



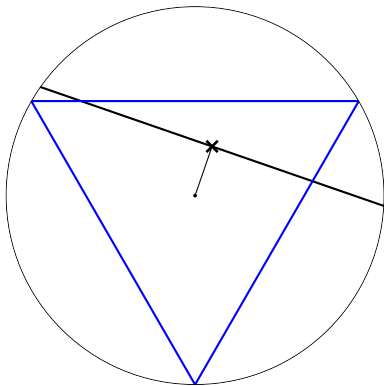
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



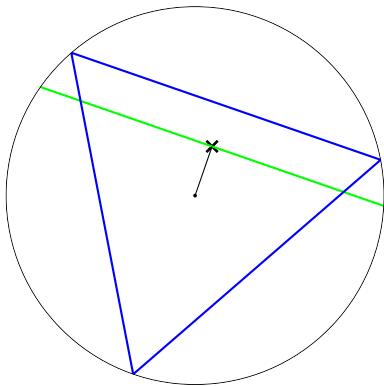
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



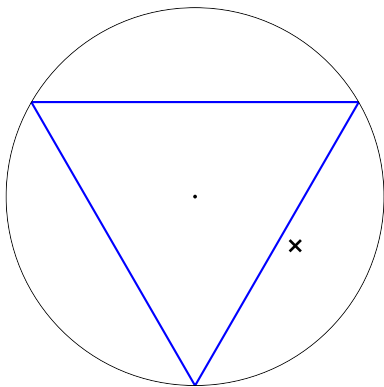
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



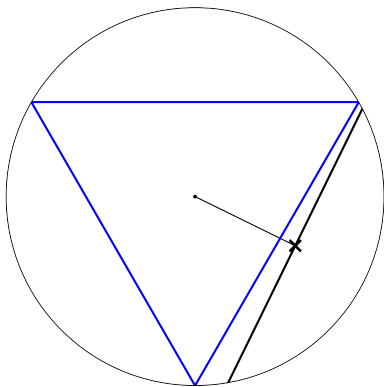
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



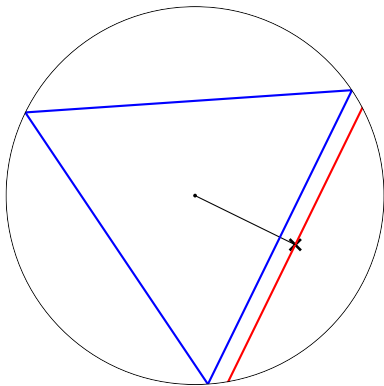
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



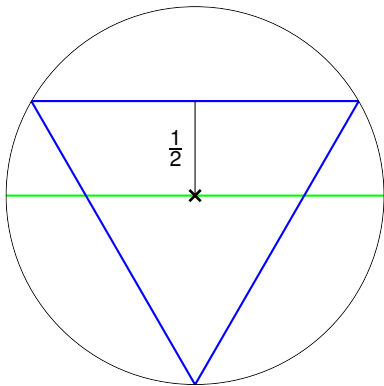
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



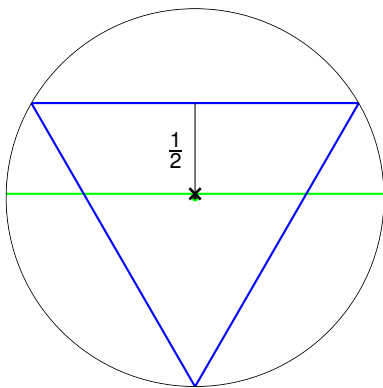
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



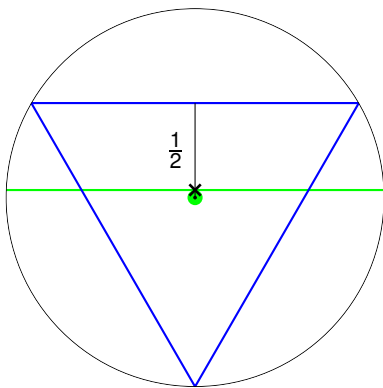
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



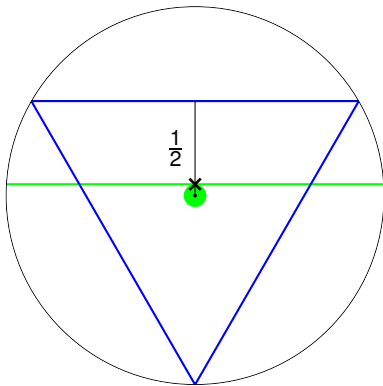
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



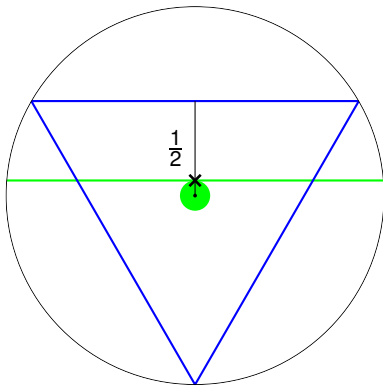
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



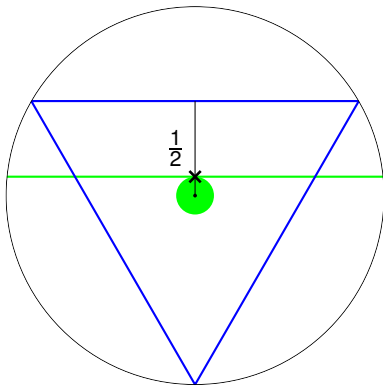
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



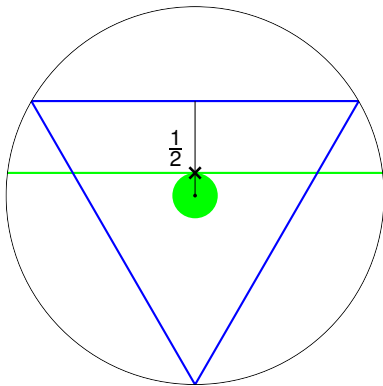
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



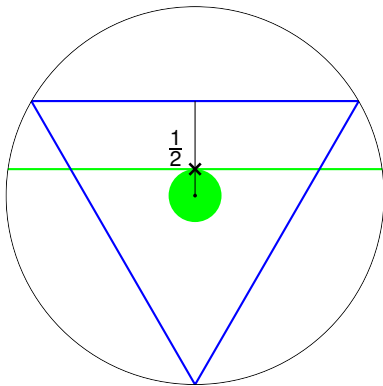
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



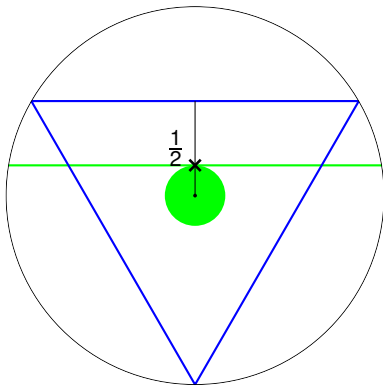
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



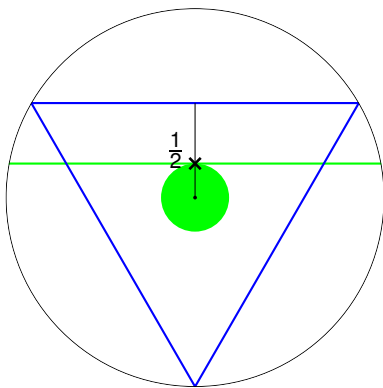
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



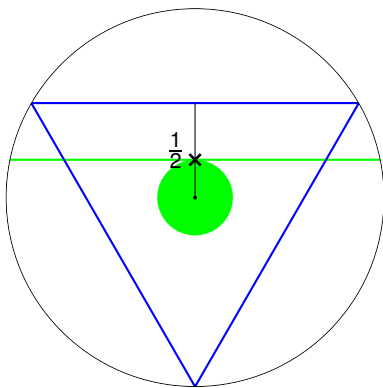
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



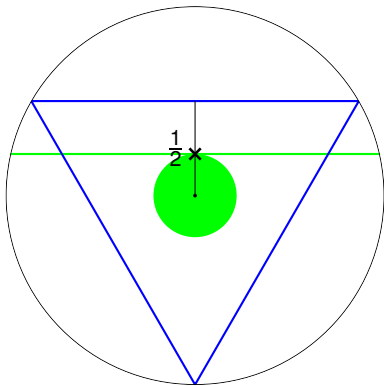
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



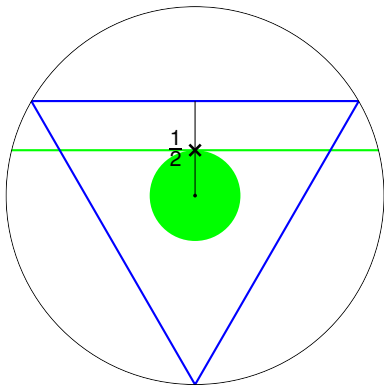
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



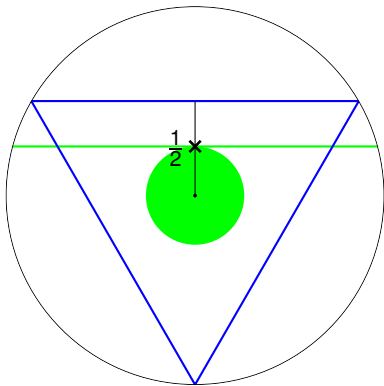
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



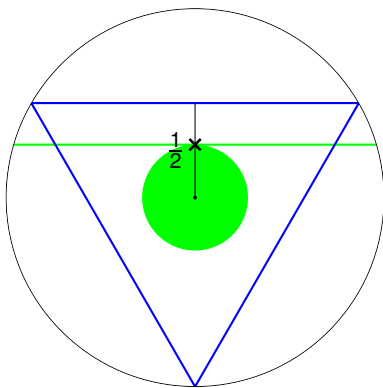
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



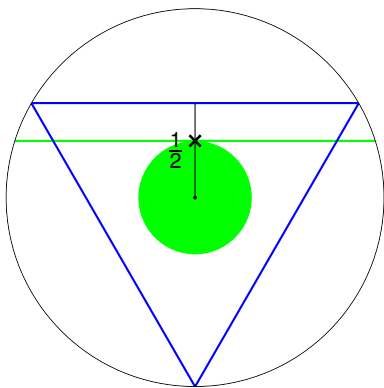
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



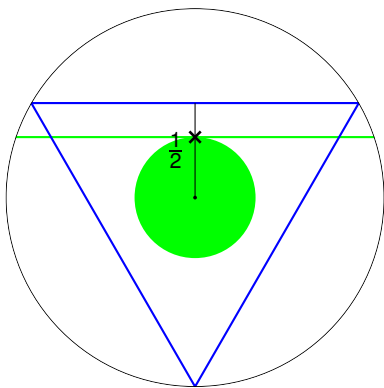
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



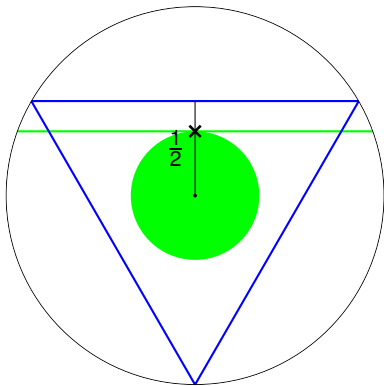
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



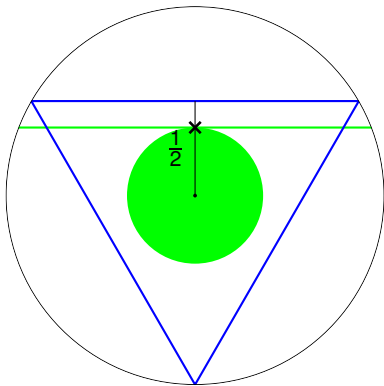
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



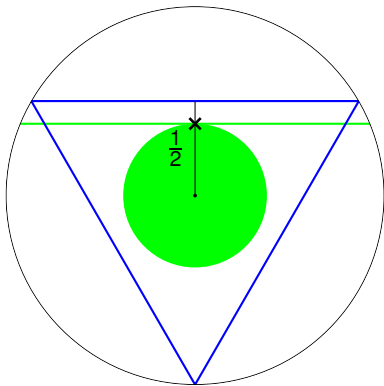
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



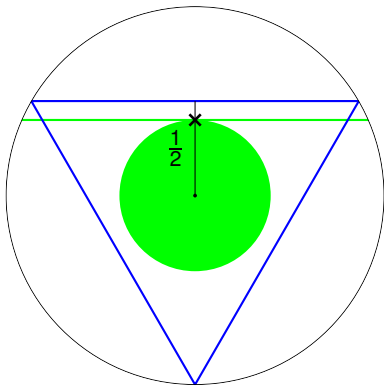
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



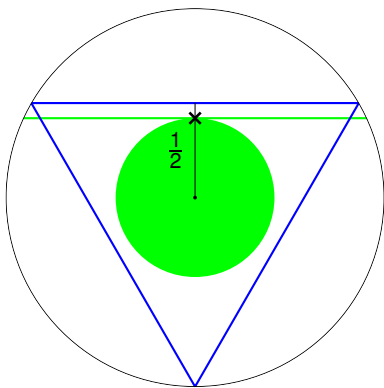
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



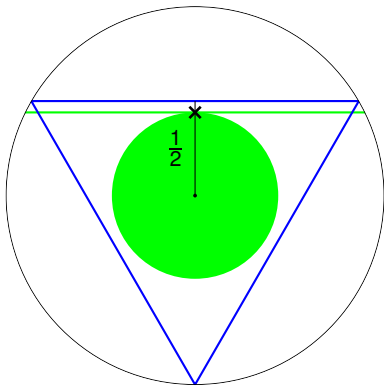
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



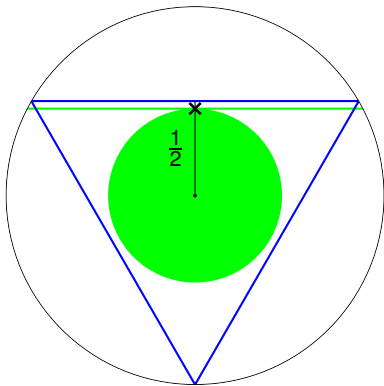
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



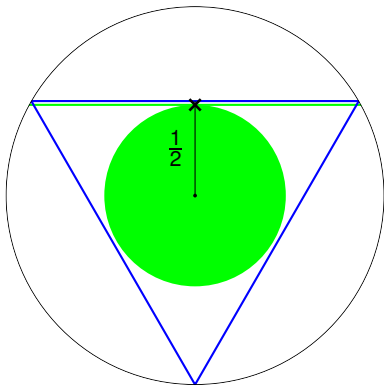
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



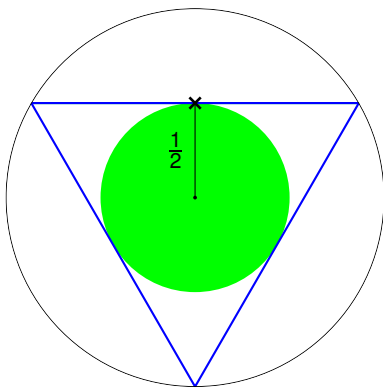
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



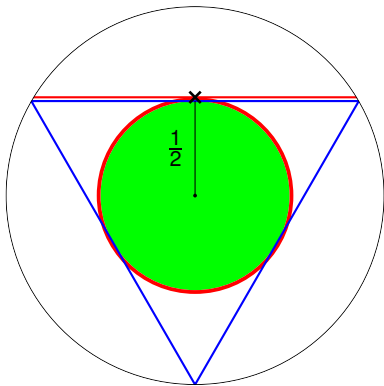
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



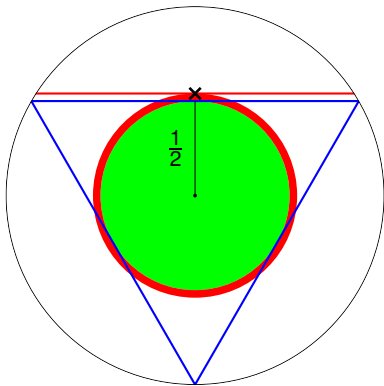
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



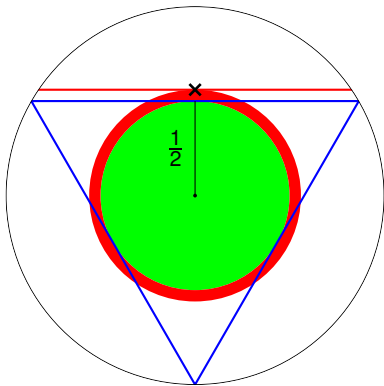
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



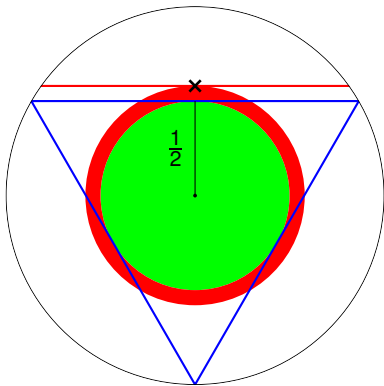
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



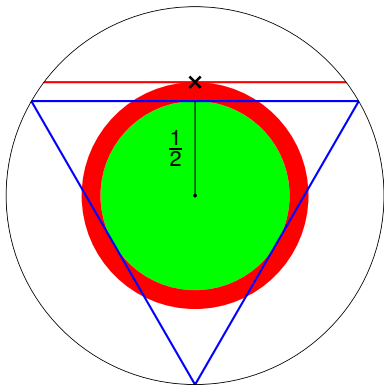
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



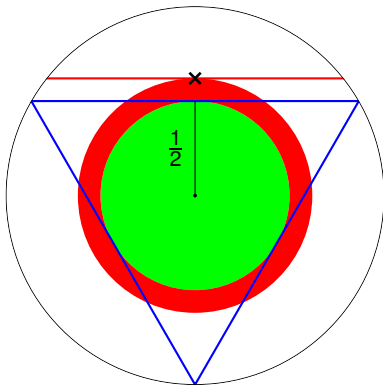
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



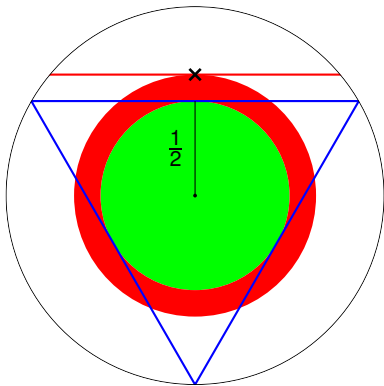
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



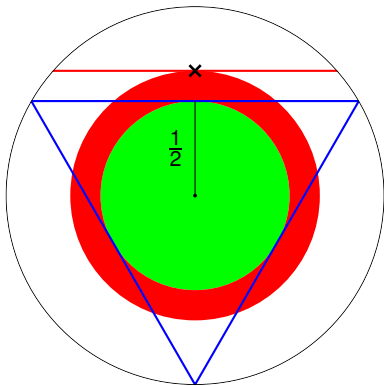
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



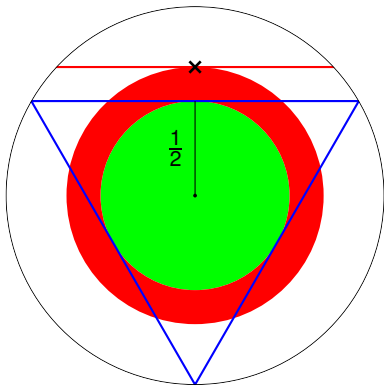
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



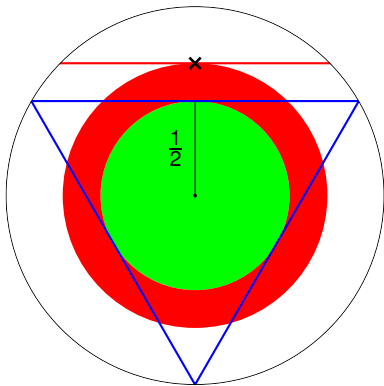
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



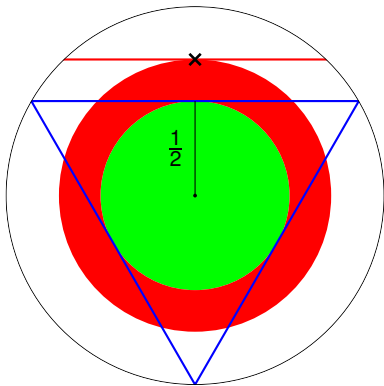
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



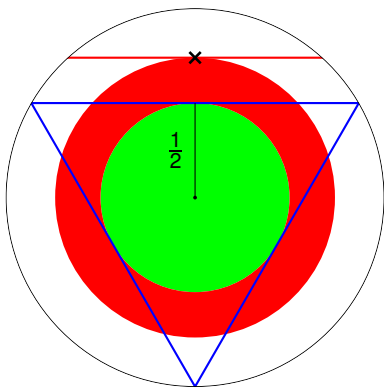
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



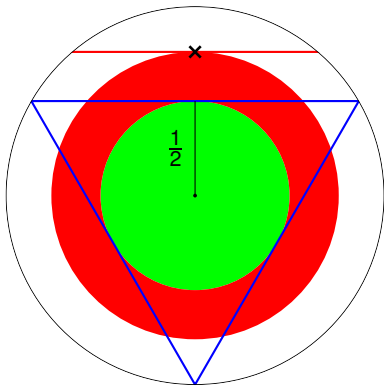
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



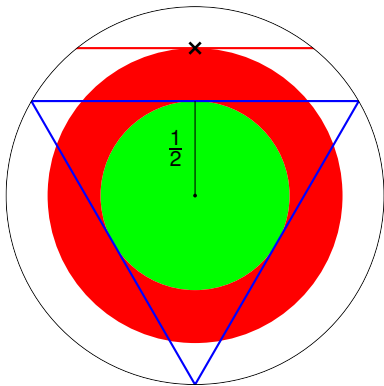
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



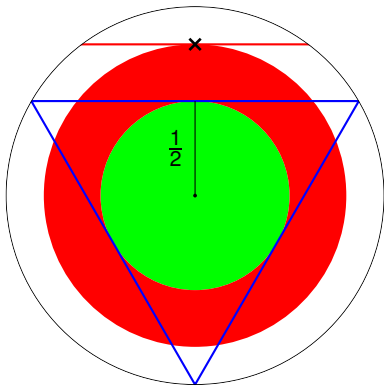
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



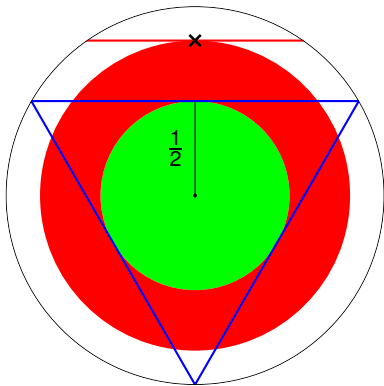
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



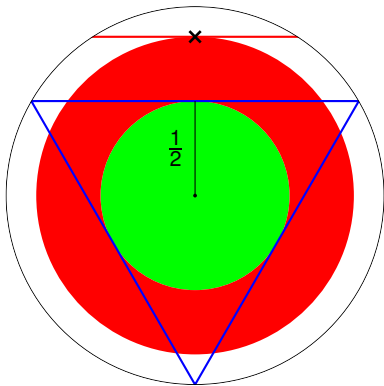
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



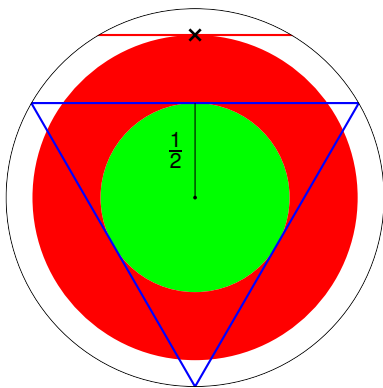
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



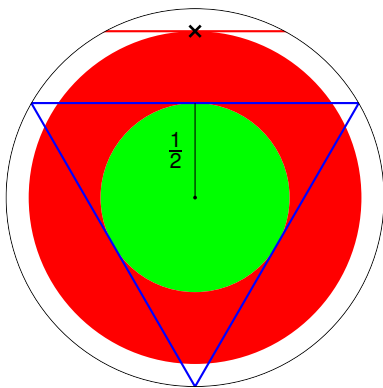
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



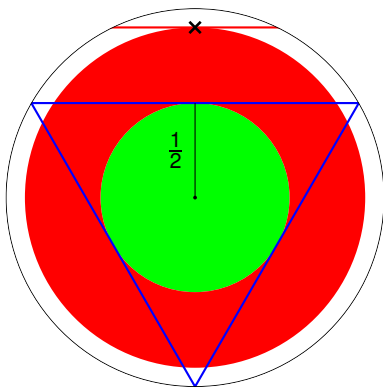
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



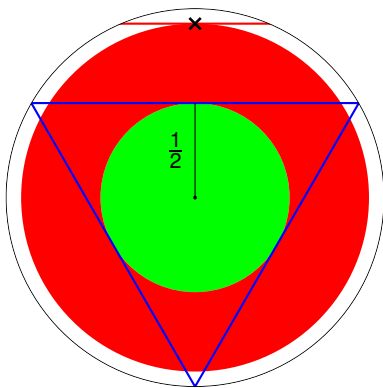
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



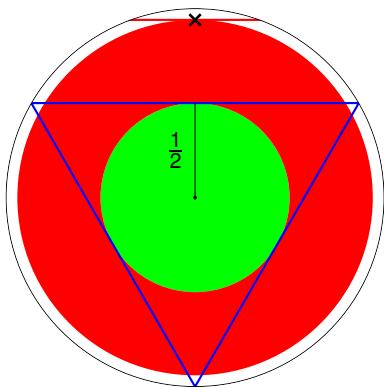
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



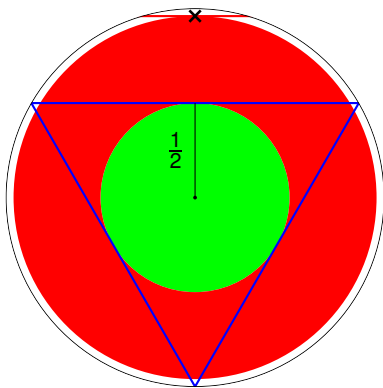
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



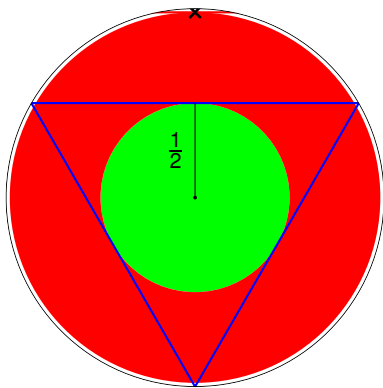
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



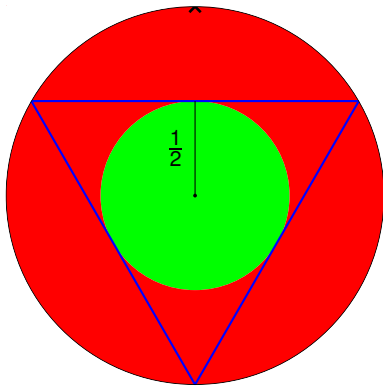
Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



Midpoint:

Oh wait. . . it's $\frac{1}{4}$!



Midpoint: $\frac{|\text{green circle}|}{|\text{red circle}|} = \frac{\left(\frac{1}{2}\right)^2 \cdot \pi}{1^2 \cdot \pi} = \frac{1}{4}$.

Answer: $\frac{1}{2}$? $\frac{1}{3}$? $\frac{1}{4}$?

Come to Bristol and we'll show you how to properly define a probability space! 😊

