

Precalculus

Compute trigonometric function of a complementary angle, part 1

Todor Milev

2019

Cofunction identities

Proposition (Cofunction identities)

$$\begin{array}{llll} \sin\left(\frac{\pi}{2} - \alpha\right) & = & \cos \alpha & \sin\left(\frac{\pi}{2} + \alpha\right) = \cos \alpha \\ \cos\left(\frac{\pi}{2} - \alpha\right) & = & \sin \alpha & \cos\left(\frac{\pi}{2} + \alpha\right) = -\sin \alpha \end{array}$$

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- The proof each formula is broken into 4 cases depending on which quadrant contains α .

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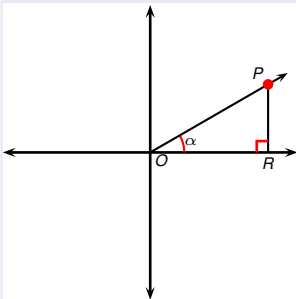
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- This makes a total of 4 formulas \times 4 cases per formula = 16 cases.
- We show only a few of the cases.
- The proof provides intuition why the formulas are true.
- The Quadrant I part of the proof serves as a visual aid for memorization.
- There is an algebraically simpler (but theoretically advanced) way to prove the above identities through the angle sum formulas, derived in turn from Euler's formula (studied later/in another course).

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Part of Proof.



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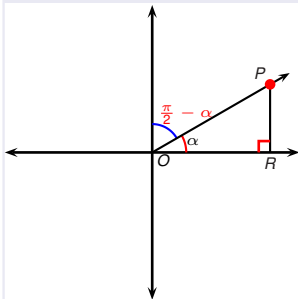


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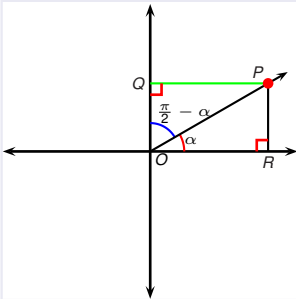


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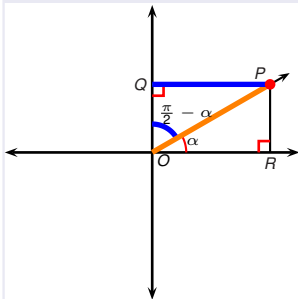


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$$\sin\left(\frac{\pi}{2} - \alpha\right) = \frac{|PQ|}{|OP|}$$

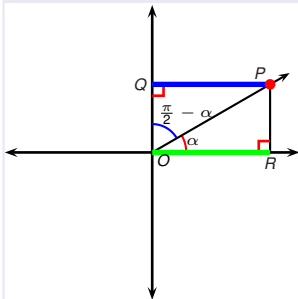


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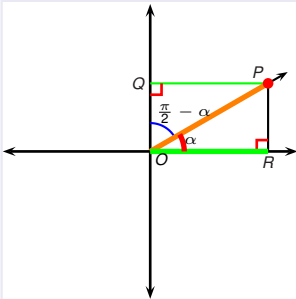


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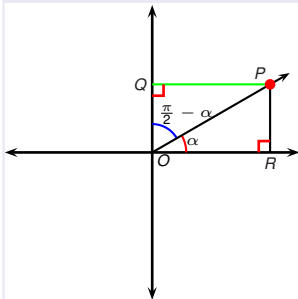


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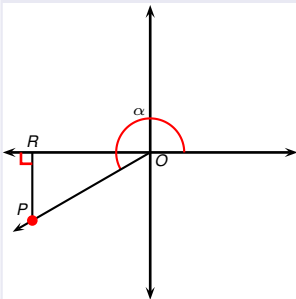


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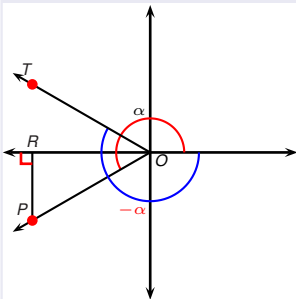


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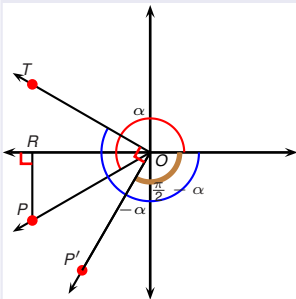


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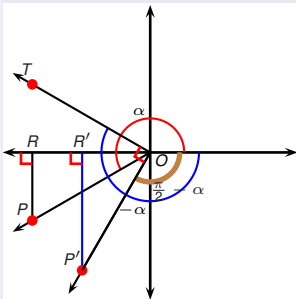


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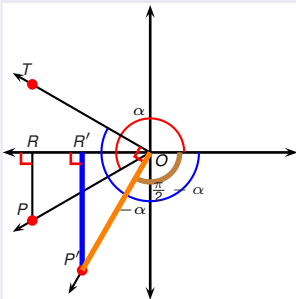


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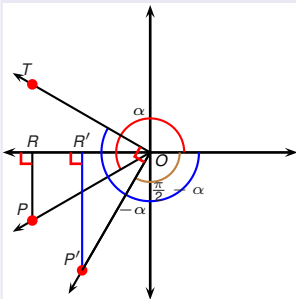


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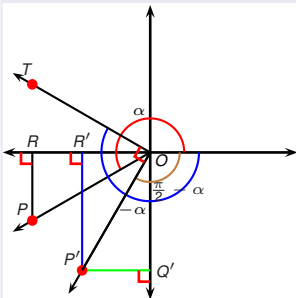


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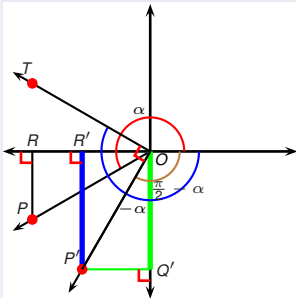


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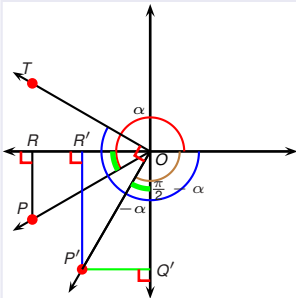


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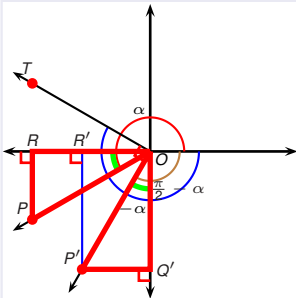
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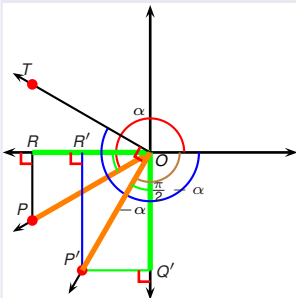


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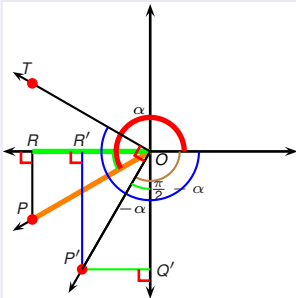
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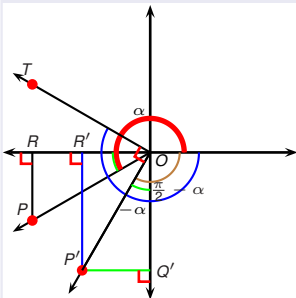


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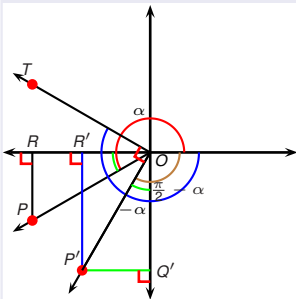
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as desired

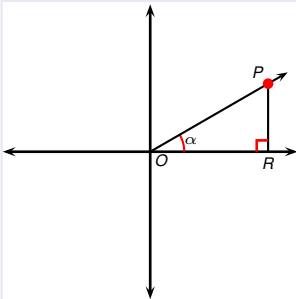


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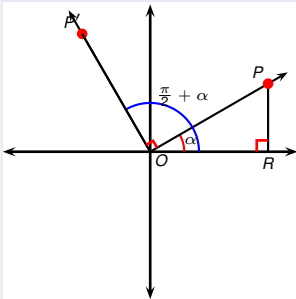


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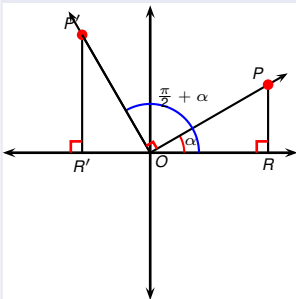


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We show $\cos\left(\frac{\pi}{2} + \alpha\right) = -\sin \alpha$ when α is in Quadrant I.

$$\cos\left(\frac{\pi}{2} + \alpha\right) =$$

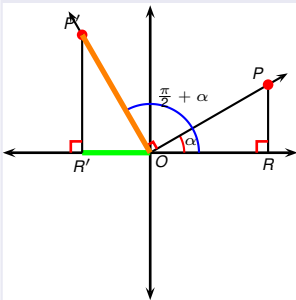


Cofunction identities

Proposition (Cofunction identities)

$$\begin{aligned}\sin\left(\frac{\pi}{2} - \alpha\right) &= \cos \alpha & \sin\left(\frac{\pi}{2} + \alpha\right) &= \cos \alpha \\ \cos\left(\frac{\pi}{2} - \alpha\right) &= \sin \alpha & \cos\left(\frac{\pi}{2} + \alpha\right) &= -\sin \alpha\end{aligned}$$

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$$\cos\left(\frac{\pi}{2} + \alpha\right) = -\frac{|OR'|}{|OP'|}$$

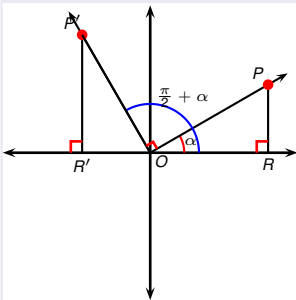


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Part of Proof.



We show $\cos\left(\frac{\pi}{2} + \alpha\right) = -\sin \alpha$ when α is in Quadrant I. It follows $\frac{\pi}{2} + \alpha$ is in Quadrant II.

$$\cos\left(\frac{\pi}{2} + \alpha\right) = -\frac{|OR'|}{|OP'|}$$

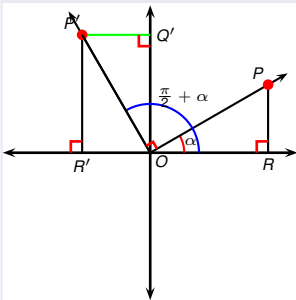


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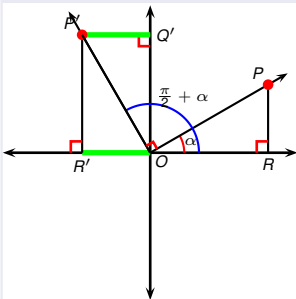


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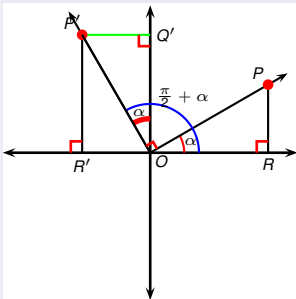


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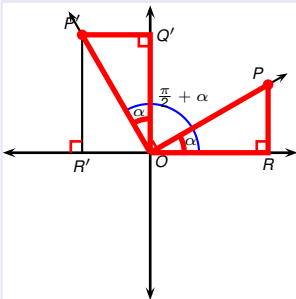


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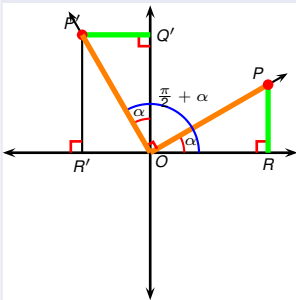


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$$\begin{aligned}\cos\left(\frac{\pi}{2} + \alpha\right) &= -\frac{|OR'|}{|OP'|} \quad \left| \square ORPQ \right. \\ &= -\frac{|P'Q'|}{|OP'|} \\ &= -\frac{|PR|}{|OP|}\end{aligned}$$

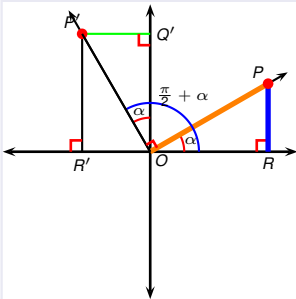


Cofunction identities

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$$\begin{aligned}\cos\left(\frac{\pi}{2} + \alpha\right) &= -\frac{|OR'|}{|OP'|} \quad \left| \square ORPQ \right. \\ &= -\frac{|P'Q'|}{|OP'|} \\ &= -\frac{|PR|}{|OP|} \\ &= -\sin \alpha.\end{aligned}$$

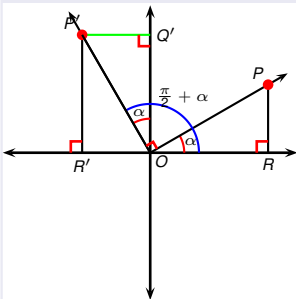
□

Cofunction identities

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We show $\cos\left(\frac{\pi}{2} + \alpha\right) = -\sin \alpha$ when α is in Quadrant I. It follows $\frac{\pi}{2} + \alpha$ is in Quadrant II.

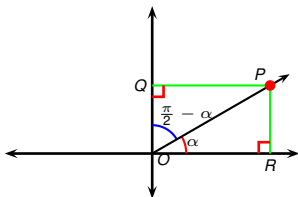
$$\begin{aligned}\cos\left(\frac{\pi}{2} + \alpha\right) &= -\frac{|OR'|}{|OP'|} && \square ORPQ \\ &= -\frac{|P'Q'|}{|OP'|} \\ &= -\frac{|PR|}{|OP|} \\ &= -\sin \alpha. && \text{as desired } \square\end{aligned}$$

Cofunction identities

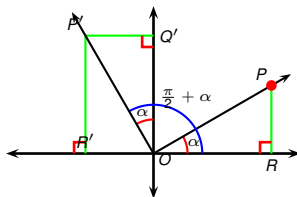
Proposition (Cofunction identities)

$$\begin{aligned}\sin\left(\frac{\pi}{2} - \alpha\right) &= \cos \alpha & \sin\left(\frac{\pi}{2} + \alpha\right) &= \cos \alpha \\ \cos\left(\frac{\pi}{2} - \alpha\right) &= \sin \alpha & \cos\left(\frac{\pi}{2} + \alpha\right) &= -\sin \alpha\end{aligned}$$

To memorize the cofunction identities it suffices to memorize the Quadrant I case via the two diagrams below.



$$\begin{aligned}\sin\left(\frac{\pi}{2} - \alpha\right) &= \frac{|PQ|}{|OP|} \\ \cos\left(\frac{\pi}{2} - \alpha\right) &= \frac{|OR|}{|OP|}\end{aligned}$$



$$\begin{aligned}\sin\left(\frac{\pi}{2} + \alpha\right) &= \frac{|OQ|}{|OP|} \\ \cos\left(\frac{\pi}{2} + \alpha\right) &= -\frac{|PQ|}{|OP|} = -\frac{|PR|}{|OP|}\end{aligned}$$