

Università degli Studi di Milano
Facoltà di Medicina e Chirurgia

CORSO DI LAUREA : INFERMIERISTICA

Corso di Fisica A.A. 2022-2023

Docente: Marie Claire Cantone

1. INTRODUZIONE

LEGGI DELLA FISICA E RUOLO DELLA MISURA

- **Le leggi della Fisica sono MODELLI MATEMATICI che riproducono l'ordine di base trovato in Natura e sono costruiti per andare a prevedere i comportamenti in Natura.**

Principio in Fisica: un modello che è sperimentalmente verificato in un esteso intervallo di condizioni.

Teoria in Fisica: un modello che è stato sperimentalmente verificato in un certo range di condizioni.

Ipotesi in Fisica: un modello non ancora verificato o verificato solo in particolari condizioni.

- **La Fisica interagisce con il mondo reale mediante il processo di misura, ovvero cerca di spiegare gli eventi, che osserviamo nel mondo attorno a noi, attraverso una descrizione matematica a partire dall' osservazione sperimentale degli stessi.**

- **La misura è la procedura che permette di associare un numero alla quantità oggetto dell'osservazione ovvero alla grandezza fisica.**

Il Sistema Internazionale di Unità di Misura (S.I.)

Introdotto nel 1960 dalla XI Conferenza Generale dei Pesi e Misure.

Inserito in Direttive della Comunità Europea fin dal 1971 ed è stato legalmente adottato in Italia nel 1982.

S.I. definisce due tipi di grandezze:

- **Grandezze fondamentali:**
  l'unità di misura è definita in modo indipendente.
- **Grandezze derivate:**
  l'unità di misura è definita tramite le relazioni analitiche che le collegano alle grandezze fondamentali

Grandezze fondamentali

Grandezza	Unità di misura	Simbolo
intervallo di tempo	secondo	s
lunghezza	metro	m
massa	chilogrammo	kg
temperatura	kelvin	K
quantità di sostanza	mole	mol
intensità di corrente	ampere	A
intensità luminosa	candela	cd

Grandezze derivate

Ad esempio, in meccanica → velocità, accelerazione, forza…

Grandezza	Unità	Simbolo	Conversione
Frequenza	hertz	Hz	$1\ Hz = 1\ s^{-1}$
Forza	newton	N	$1\ N = 1\ kg\ m\ s^{-2}$
Pressione	pascal	Pa	$1\ Pa = 1\ N\ m^{-2}$
Lavoro, energia	joule	J	$1\ J = 1\ N\ m$
Potenza	watt	W	$1\ W = 1\ J\ s^{-1}$

Unità di misura legate ad un nome proprio di persona

Grandezze scalari e vettoriali

Grandezze scalari

Grandezze che sono caratterizzate attraverso un numero che indica l'ammontare della grandezza considerata (il rapporto fra la grandezza e la sua unità di misura)

Esempi: un intervallo di tempo di 3 s, una massa di 45 kg, una frequenza di 105.5 MHz, una pressione di 1 atm . . .

Grandezze scalari e vettoriali

Grandezze vettoriali

Grandezze che sono caratterizzate attraverso :

- **un numero che indica l'ammontare della grandezza (detto modulo o intensità)**
- **una direzione**
- **un verso**

Esempi: lo spostamento, la velocità, la forza



Sistema c.g.s. di unità di misura

- centimetro (cm)
- grammo (g)
- secondo (s)

Il S.I. si basa sul sistema MKS metro (m), chilogrammo (kg), secondo (s).

$1\ m = 10^{2}\ cm$

$1\ m^2 = 10^{4}\ cm^{2}$

$1\ m^3 = 10^{6}\ cm^{3}$

$1\ kg = 10^{3}\ g$

$1\ cm = 10^{?}\ m$

$1\ cm^{2} = 10^{-4}\ m^{2}$

$1\ cm^{3} = 10^{-6}\ m^{3}$

$1\ g = 10^{?}\ kg$



Sistema pratico

alcuni esempi

Grandezza	Unità	Simbolo	Conversione
Volume	litro	l	1 l = 10^{-3} m^3
Massa	tonnellata	t	1 t = 10^3 kg
Tempo	minuto	min	1 min = 60 s
Tempo	ora	h	1 h = 3600 s
Energia	elettronvolt	eV	1 eV = 1.6 x 10^{-19} J
Pressione	millimetro di mercurio	mm Hg	1 mm Hg = 133 Pa

Prefissi Moltiplicativi per multipli e sottomultipli delle unità di misura

Fattore	Prefisso	Simbolo	Fattore	Prefisso	Simbolo
10^{24}	yotta-	Y-	10^{-24}	yocto-	y-
10^{21}	zetta-	Z-	10^{-21}	zepto-	z-
10^{18}	exa-	E-	10^{-18}	atto-	a-
10^{15}	peta-	P-	10^{-15}	femto-	f-
10^{12}	tera-	T-	10^{-12}	pico-	p-
10^{9}	giga-	G-	10^{-9}	nano-	n-
10^{6}	mega-	M-	10^{-6}	micro-	μ-
10^{3}	chilo-	k-	10^{-3}	milli-	m-
10^{2}	etto-	h-	10^{-2}	centi-	c-
10	deca-	da-	10^{-1}	deci-	d-

Prefissi Moltiplicativi per multipli e sottomultipli delle unità di misura

Fattore	Prefisso	Simbolo	Fattore	Prefisso	Simbolo
10^{24}	yotta-	Y-	10^{-24}	yocto-	y-
10^{21}	zetta-	Z-	10^{-21}	zepto-	z-
10^{18}	exa-	E-	10^{-18}	atto-	a-
10^{15}	peta-	P-	10^{-15}	femto-	f- m
10^{12}	tera-	T-	10^{-12}	pico-	p- C
10^{9}	giga-	G- Hz	10^{-9}	nano-	n-
10^{6}	mega-	M- m	10^{-6}	micro-	μ- g
10^{3}	chilo-	k- m	10^{-3}	milli-	m- m
10^{2}	etto-	h- l	10^{-2}	centi-	c- l
10	deca-	da-	10^{-1}	deci-	d-

Usare le potenze di 10 nelle conversioni

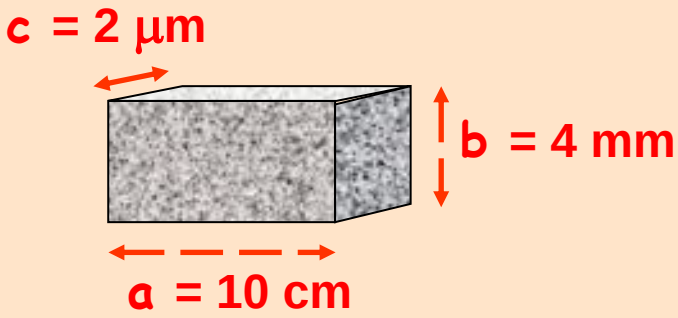
$1\ cm = 0.01\ m \rightarrow 10^{-2}\ m$

$1\ dm = 10^{-1}\ m$

$1\ \mu m = 10^{-6}\ m$

$1\ dm^3 = ?\ m^3$

$1\ nm = 10^{-9}\ m$



$V = ?$

$a = 10\ cm = \ldots\ m$

$b = 4\ mm = \ldots\ m$

$c = 2\ \mu m = \ldots\ m$

$V = \ldots\ldots\ldots\ m^3$

Usare le potenze di 10 nelle conversioni

$1\ cm = 0.01\ m \rightarrow 10^{-2}\ m$

$1\ dm = 10^{-1}\ m$

$1\ \mu m = 10^{-6}\ m$

$1\ dm^3 = ?\ m^3$

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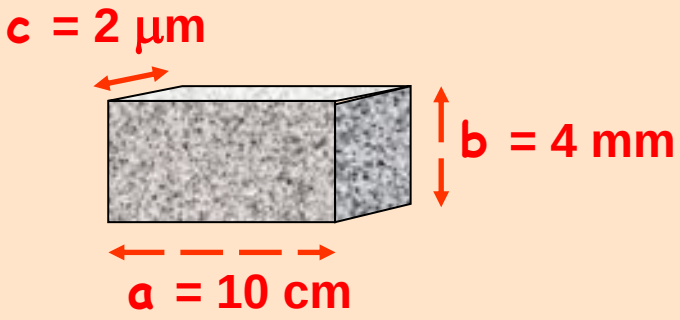

$V = ?$

$a = 10\ cm = 10^{-1}\ m$

$b = 4\ mm = 4 \cdot 10^{-3}\ m$

$c = 2\ \mu m = 2 \cdot 10^{-6}\ m$

$V = a \times b \times c = 8 \cdot 10^{-10}\ m^3$

Usare le potenze di 10 nelle conversioni

$1\ cm = 0.01\ m \rightarrow 10^{-2}\ m$

$1\ dm = 10^{-1}\ m$

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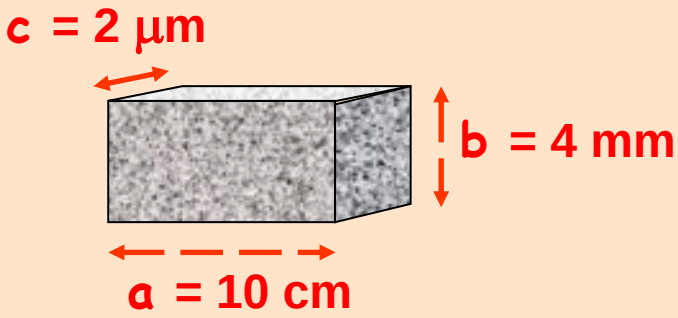

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$10\ cm$

$4 \cdot 10^{-1}\ cm$

$2 \cdot 10^{-4}\ cm$

$V = a \times b \times c = 8 \cdot 10^{-10}\ m^3$

$8 \cdot 10^{-4}\ cm^3$

Usare le potenze di 10 nelle conversioni

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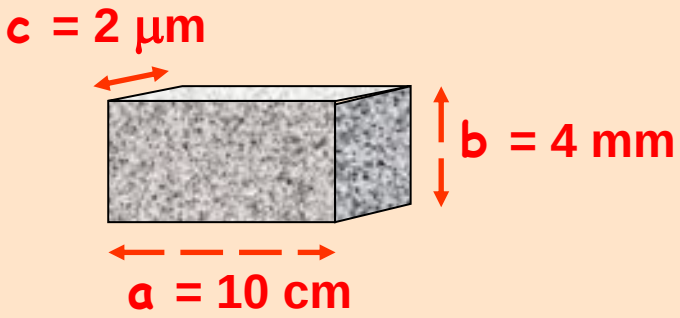

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$10\ cm$

$4 \cdot 10^{-1}\ cm$

$2 \cdot 10^{-4}\ cm$

$V = a \times b \times c = 8 \cdot 10^{-10}\ m^3$

$8 \cdot 10^{-4}\ cm^3$

$8 \cdot 10^{-1}\ mm^3$

Ad esempio densità ρ

grandezza derivata

$$\rho = \frac{m}{V}$$

grandezza fondamentale

grandezza derivata

Unità di misura di ρ è derivata dalle unità di misura di m e di V

Nel S.I. ρ si misura in kg m^{-3}

$$\rho_{H_2O} = 1 \ g/cm^3$$

$$\rho_{H_2O} = \ldots \ kg/m^3$$

$$\rho_{H_2O} = \ldots \ kg/l$$

Ad esempio densità ρ

grandezza derivata

$$\rho = \frac{m}{V}$$

grandezza fondamentale

grandezza derivata

Unità di misura di ρ è derivata dalle unità di misura di m e di V

Nel S.I. ρ si misura in kg m^{-3}

ρ_{H_2O} = **1 g/cm^3**

ρ_{H_2O} = **1000 kg/m^3**

ρ_{H_2O} = **… kg/l**

$$1\ \frac{g}{cm^3} = \frac{10^{-3}\,kg}{10^{-6}\,m^3} = 10^3\ \frac{kg}{m^3}$$

Ad esempio densità ρ

grandezza derivata

$$\rho = \frac{m}{V}$$

grandezza fondamentale

grandezza derivata

Unità di misura di ρ è derivata dalle unità di misura di m e di V

Nel S.I. ρ si misura in kg m^{-3}

$$\rho_{H_2O} = 1 \ g/cm^3$$

$$\rho_{H_2O} = 1000 \ kg/m^3$$

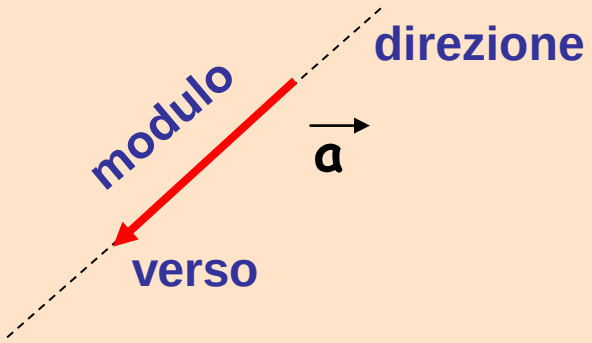
$$\rho_{H_2O} = 1 \ kg/l$$

$$1\ \frac{g}{cm^3} = \frac{10^{-3}\,kg}{10^{-6}\,m^3} = 10^3\ \frac{kg}{m^3}$$

esempio **densità alluminio = 2.7 g/cm³ = 2700 kg/ m³**

RICHIAMI SUI VETTORI

VETTORE



$\vec{a}$ { modulo **a**, direzione, verso

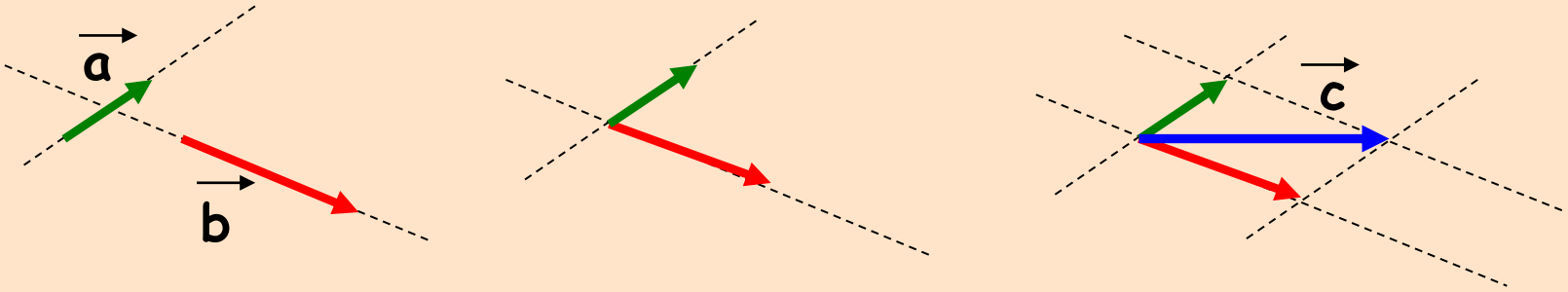
a è il modulo del vettore $\vec{a}$

un vettore è indicato con la lettera che lo rappresenta, in modi diversi:

- **in grassetto** (**v**)
- **sottolineata** ($\underline{v}$)
- **con sopra una freccetta** ($\vec{v}$)

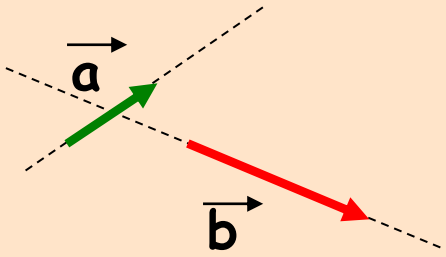
SOMMA DI VETTORI

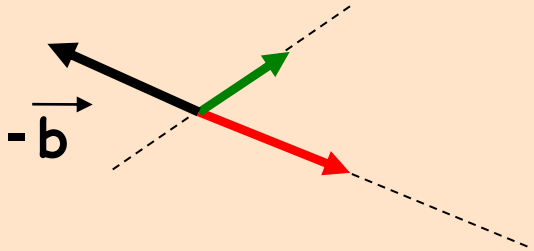
regola del parallelogrammo

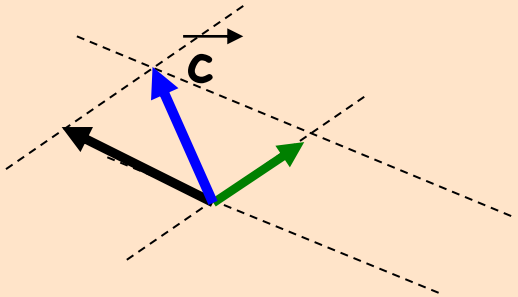


$$\vec{a} + \vec{b} = \vec{c}$$

DIFFERENZA DI VETTORI





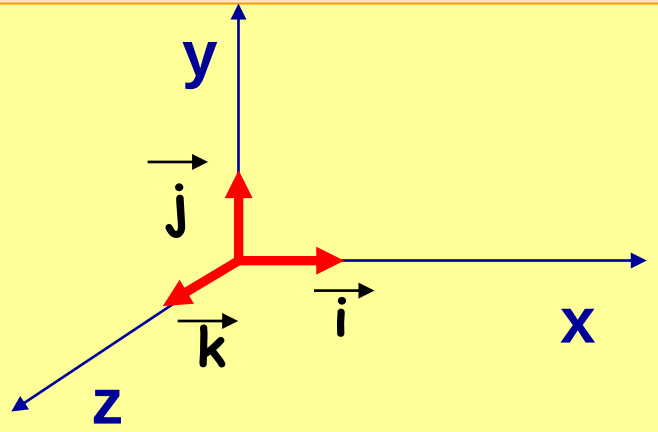


$$\vec{a} - \vec{b} = \vec{a} + (-\vec{b}) = \vec{c}$$

VERSORE

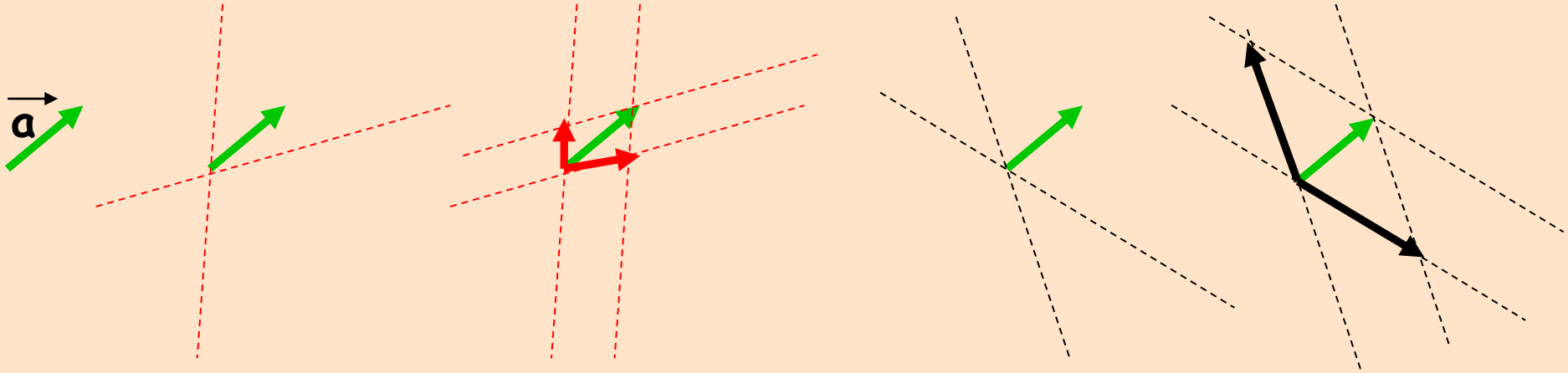
$$\vec{n} = \frac{\vec{a}}{a}$$

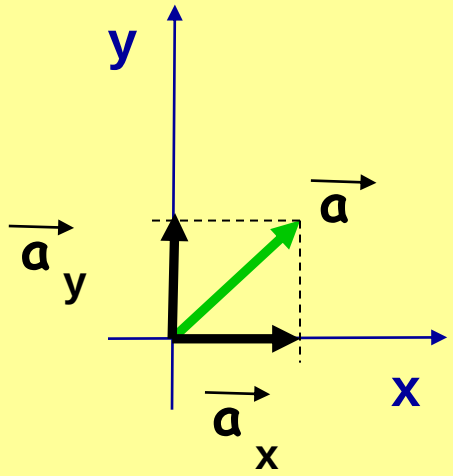
- modulo 1
- direzione di $\vec{a}$
- verso $\vec{a}$



Ad esempio i versori per gli assi

SCOMPOSIZIONE DI UN VETTORE



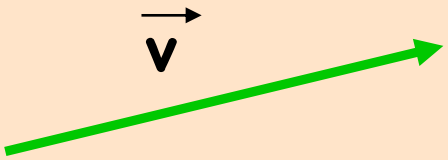


$\vec{a}_x$ e $\vec{a}_y$ sono i vettori componenti ortogonali di $\vec{a}$

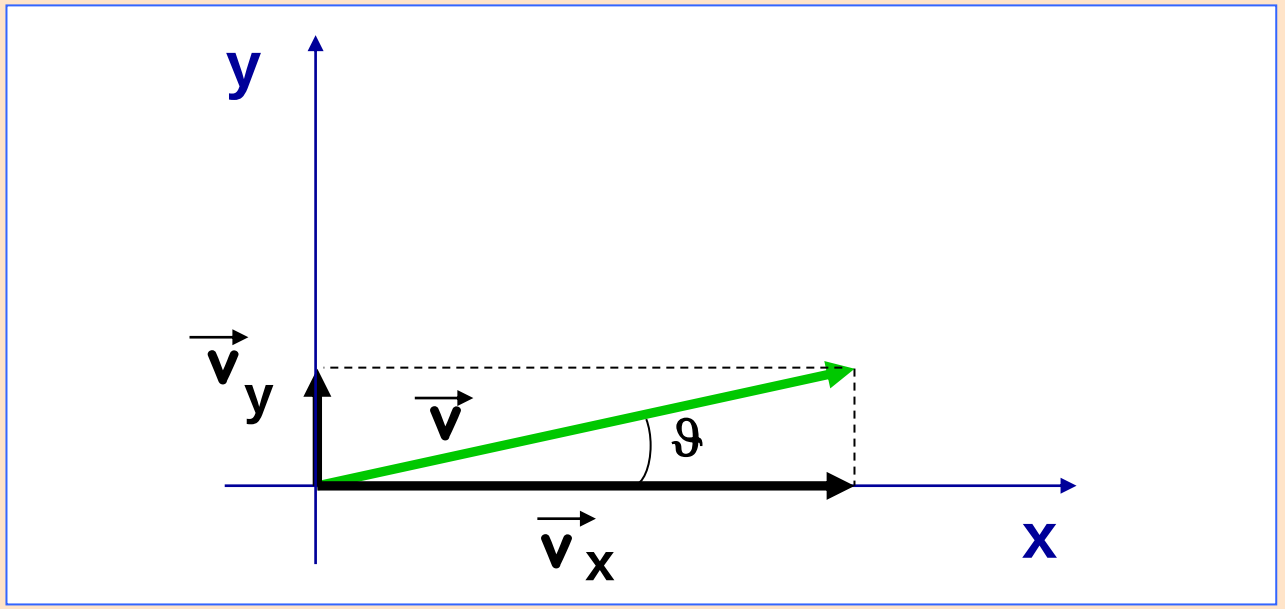
a_x e a_y sono le componenti ortogonali di $\vec{a}$

$$\vec{a} = \vec{a}_x + \vec{a}_y$$

$$\vec{a} = a_x \vec{i} + a_y \vec{j}$$



$$\vec{v} = \vec{v}_x + \vec{v}_y$$



$$v_x = v \cos \vartheta$$

$$v_y = v \operatorname{sen} \vartheta$$

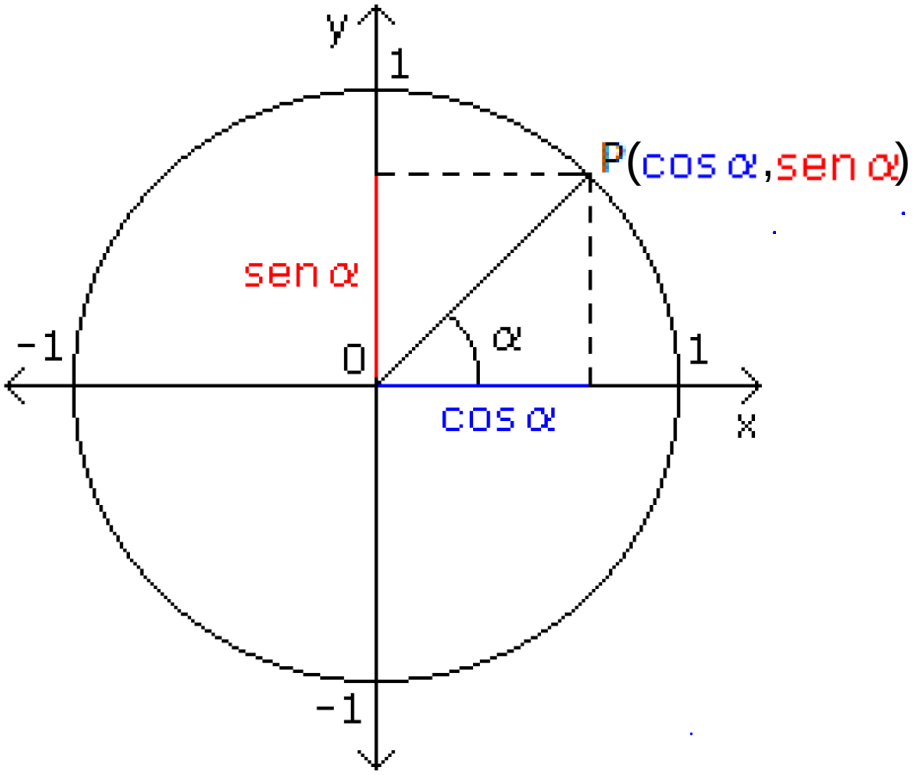
$$v = \sqrt{v_x^2 + v_y^2}$$

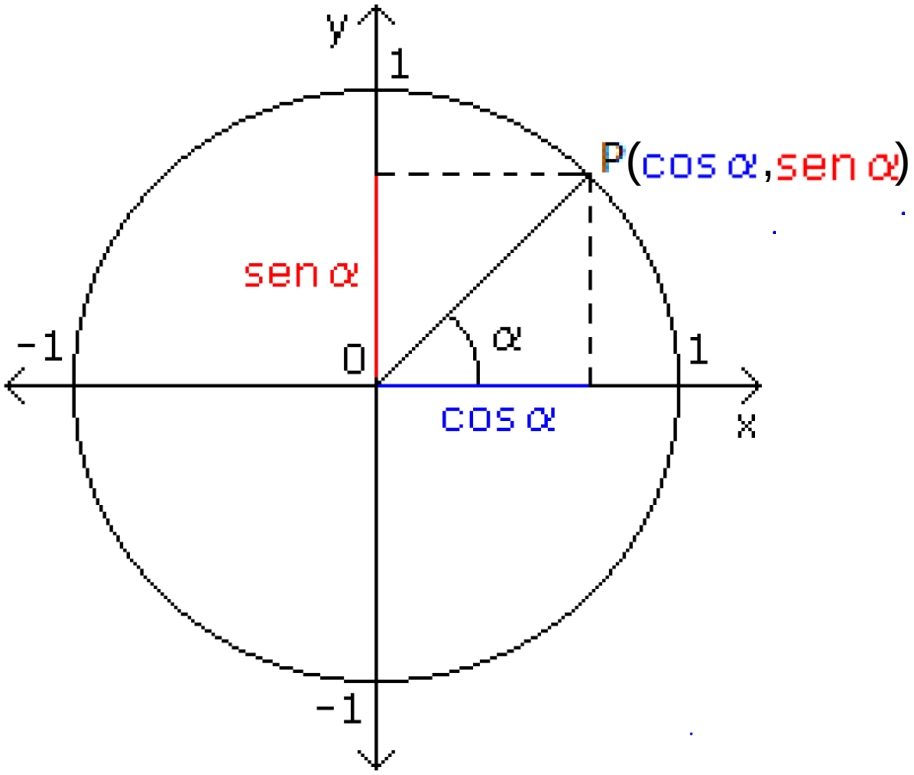
Esempio

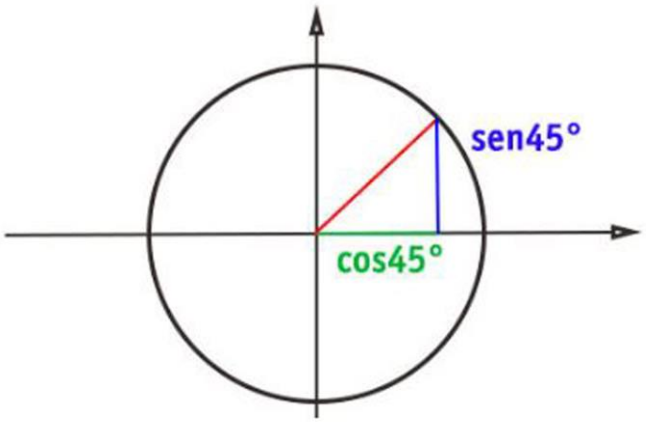
$v = 10, \ \vartheta = 30°$

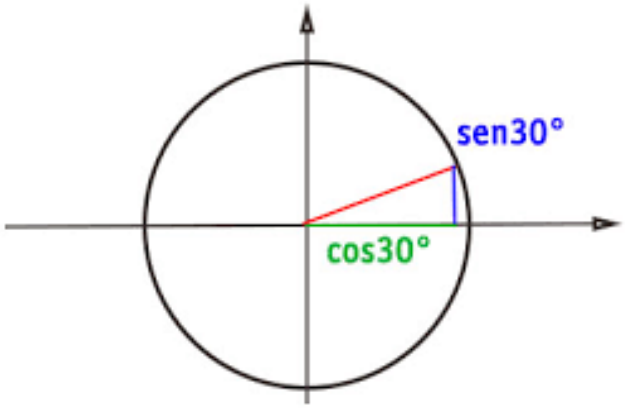
Esempio

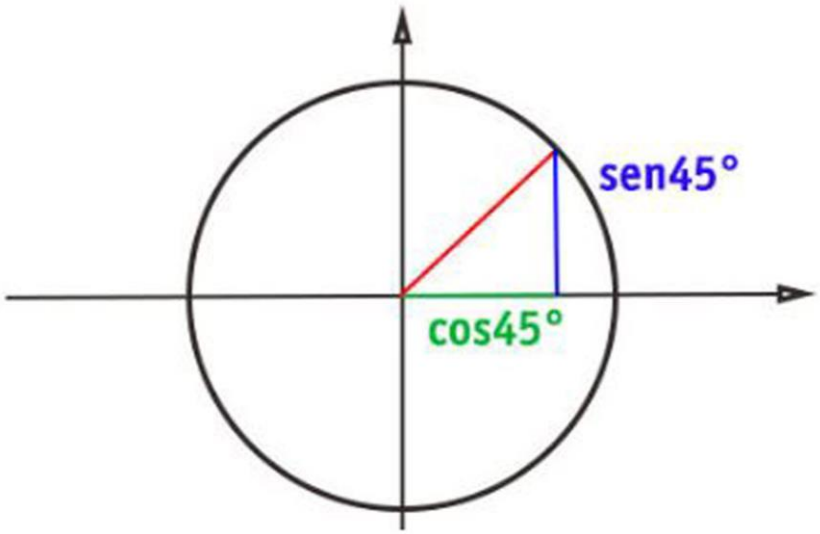
$v = 8, \ \vartheta = 45°$

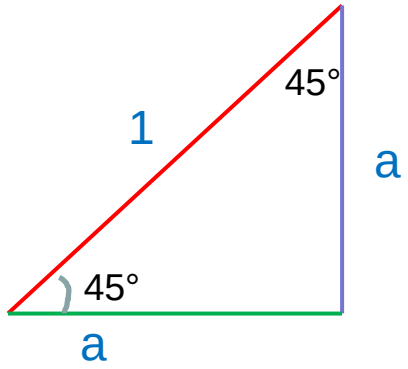

y
1
P(cos α,sen α)
sen α
-1
0
α
1
cos α
x
-1


y
1
P(cos α,sen α)
sen α
-1
0
α
1
cos α
x
-1

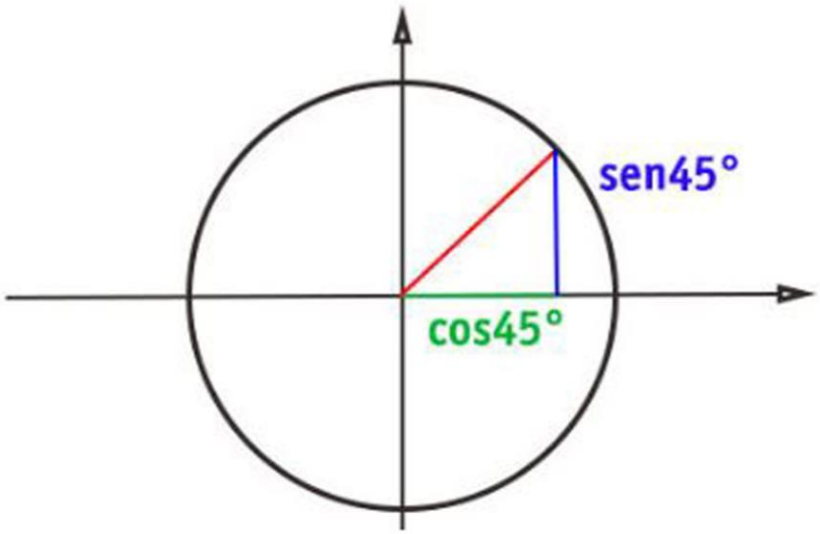

sen45°
cos45°

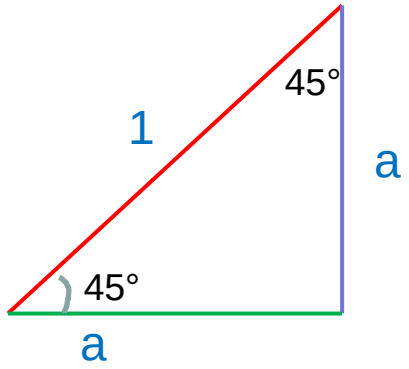

sen30°
cos30°





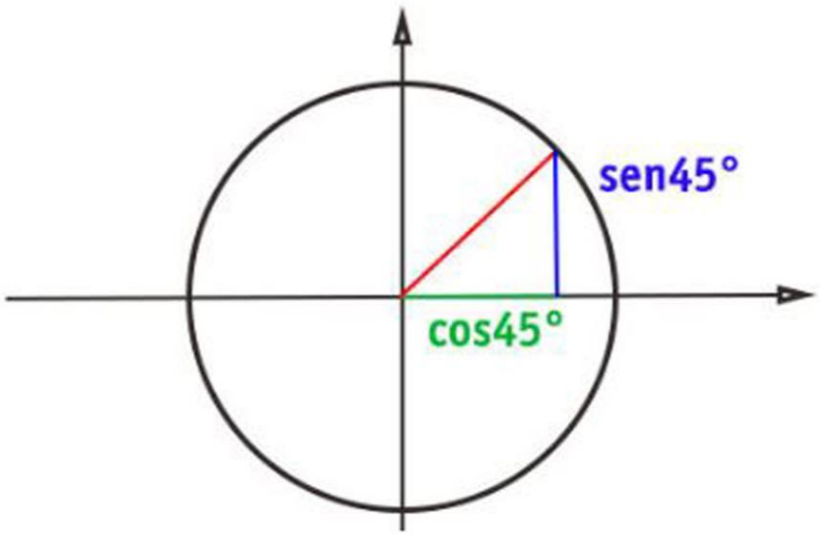
$a^2 + a^2 = 1$ $\quad 2\,a^2 = 1$ $\quad a^2 = \frac{1}{2}$

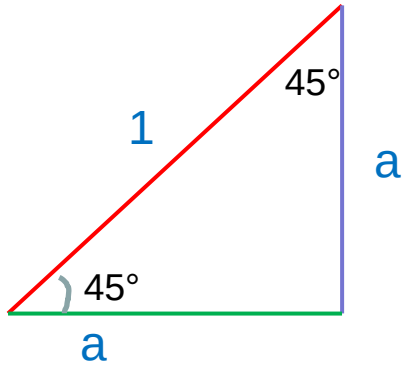




$a^2 + a^2 = 1$ $\quad 2a^2 = 1$ $\quad a^2 = \frac{1}{2}$

$a = \frac{1}{\sqrt{2}}$ $\quad a = \frac{1}{\sqrt{2}} \cdot \frac{\sqrt{2}}{\sqrt{2}}$ $\quad \Rightarrow \quad a = \frac{\sqrt{2}}{2}$





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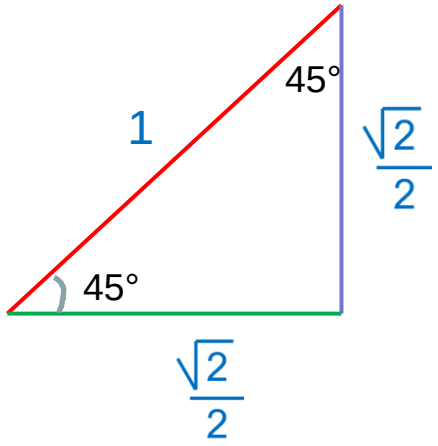
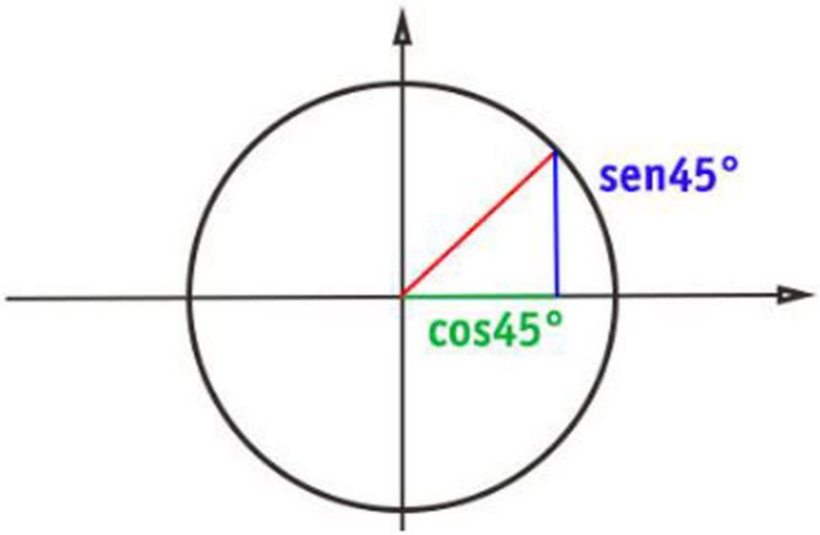
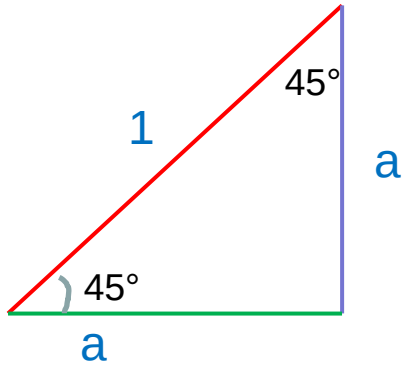
$a = \frac{1}{\sqrt{2}} \qquad a = \frac{1}{\sqrt{2}} \cdot \frac{\sqrt{2}}{\sqrt{2}} \Rightarrow a = \frac{\sqrt{2}}{2}$

$\text{sen } 45° = \cos 45° = \frac{\sqrt{2}}{2}$







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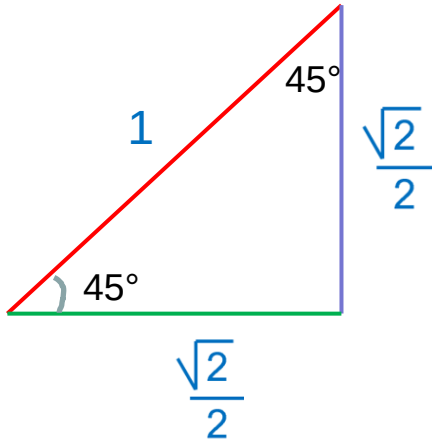
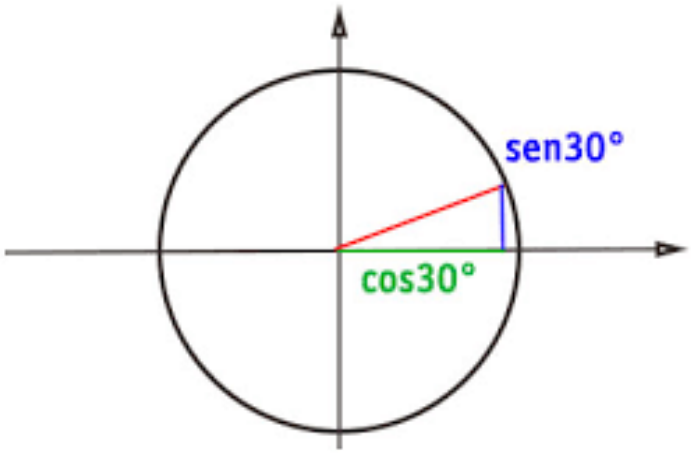
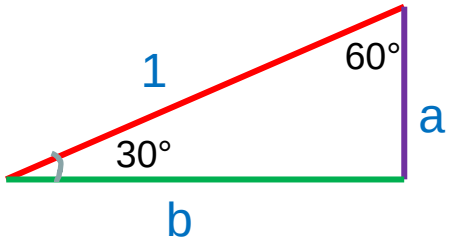
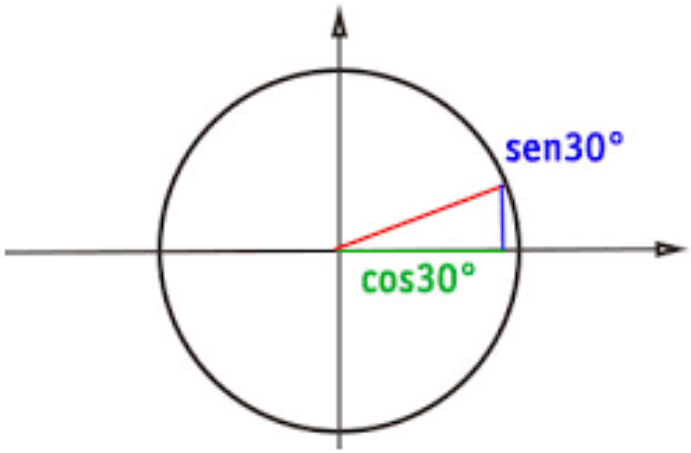
$\text{sen } 45° = \cos 45° = \frac{\sqrt{2}}{2}$

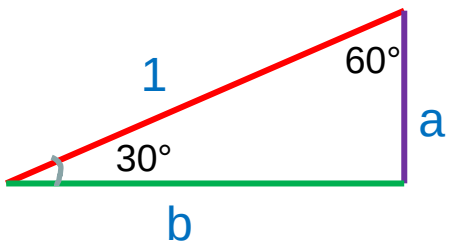
1.414 /2 = 0.707

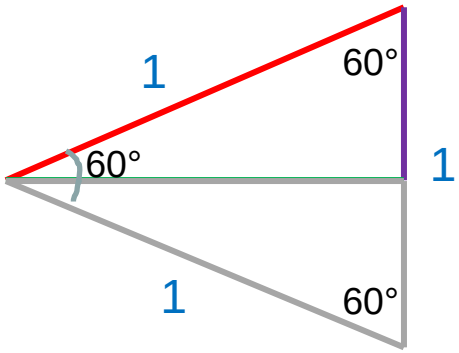


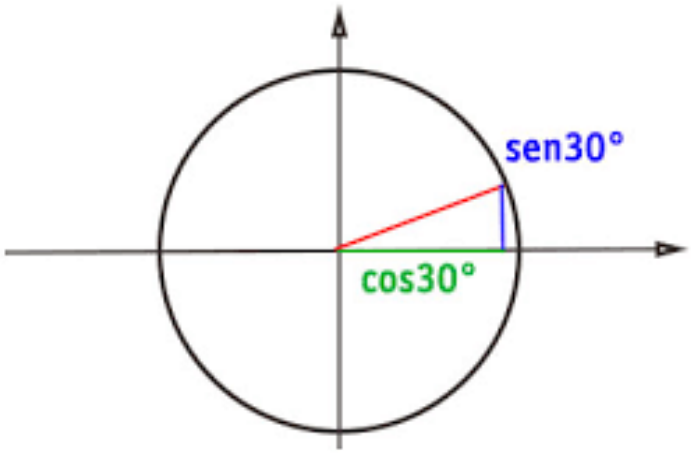

sen30°
cos30°

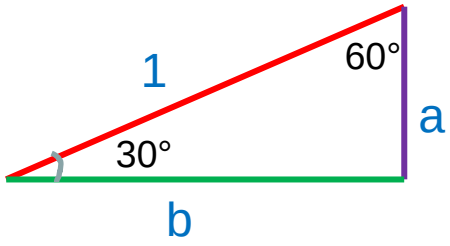

1
60°
a
30°
b

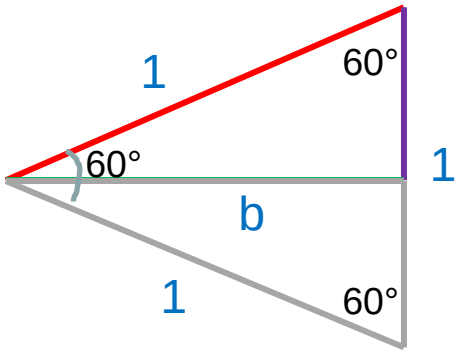

sen30°
cos30°


1
60°
a
30°
b


1
60°
60°
1
1
60°

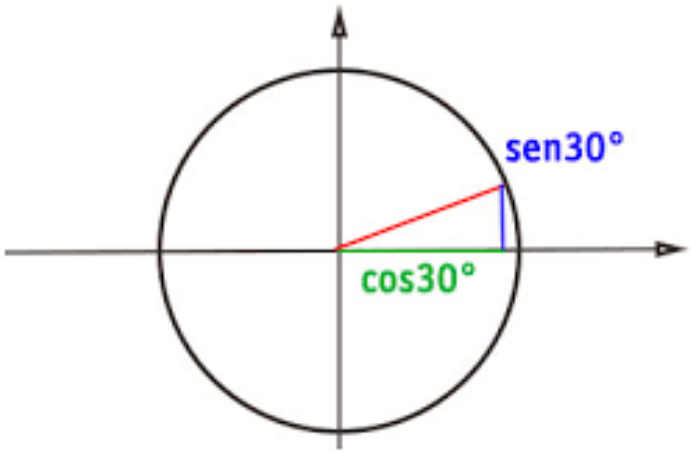


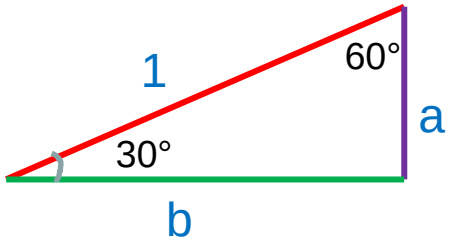


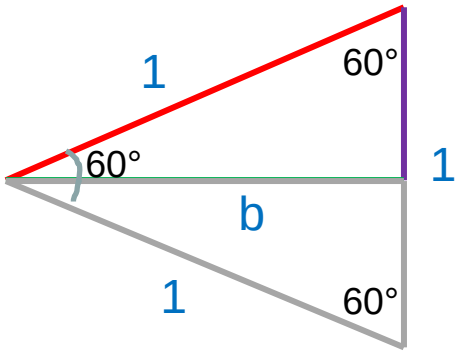


$$a = \frac{1}{2}$$

$$a^2 + b^2 = 1$$







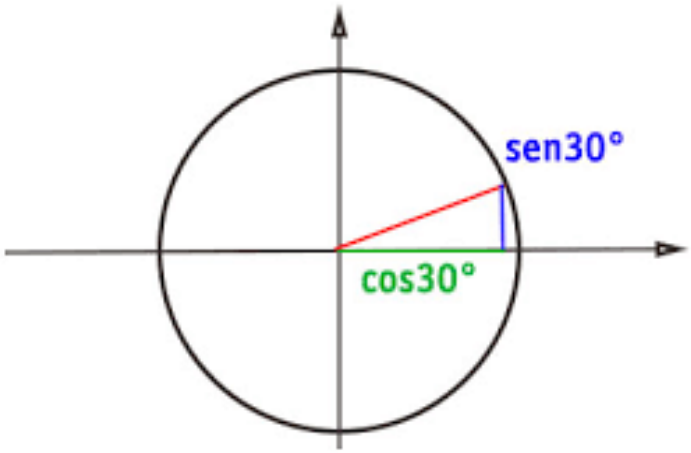
$$a = \frac{1}{2}$$

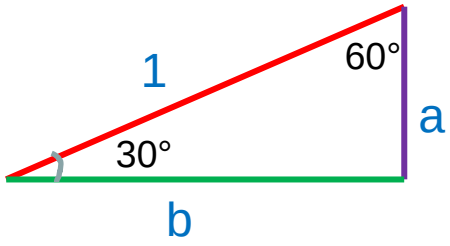
$$a^2 + b^2 = 1$$

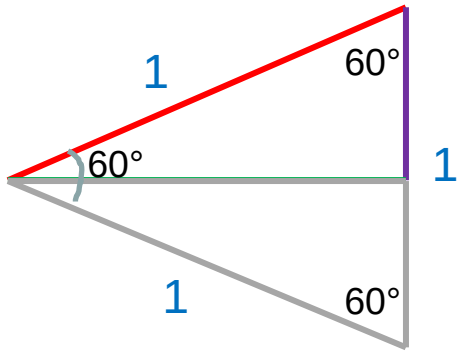
$$b^2 = 1 - a^2$$

$$b^2 = 1 - \frac{1}{4}$$

$$b^2 = \frac{3}{4} \quad \Rightarrow \quad b = \frac{\sqrt{3}}{2}$$







$$a = \frac{1}{2}$$

$$a^2 + b^2 = 1$$

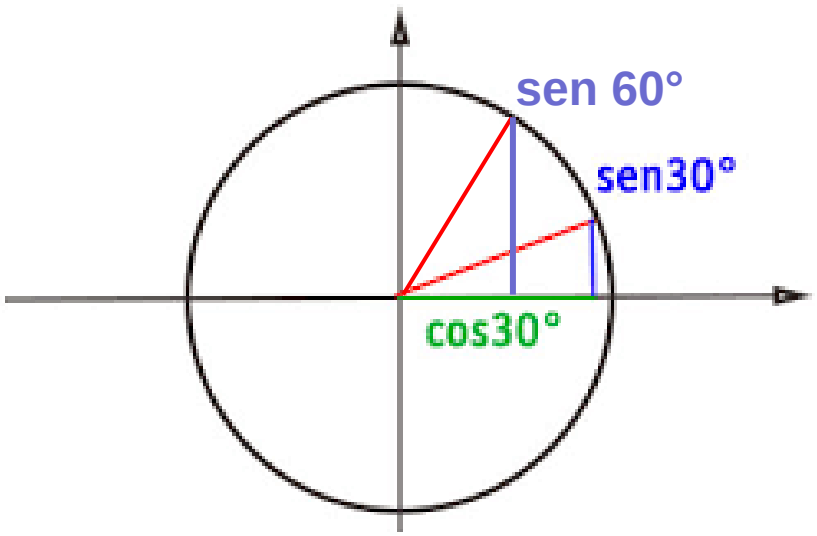
$$b^2 = 1 - a^2$$

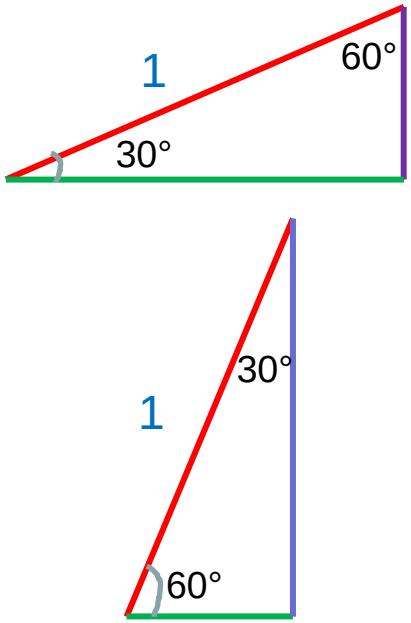
$$b^2 = 1 - \frac{1}{4}$$

$$b^2 = \frac{3}{4} \Rightarrow b = \frac{\sqrt{3}}{2}$$

$$\text{sen } 30° = \frac{1}{2}$$

$$\cos 30° = \frac{\sqrt{3}}{2}$$

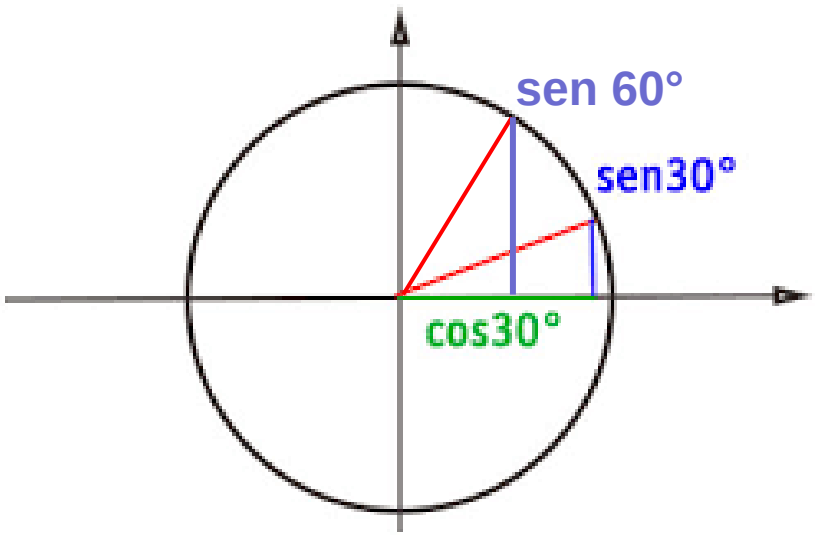


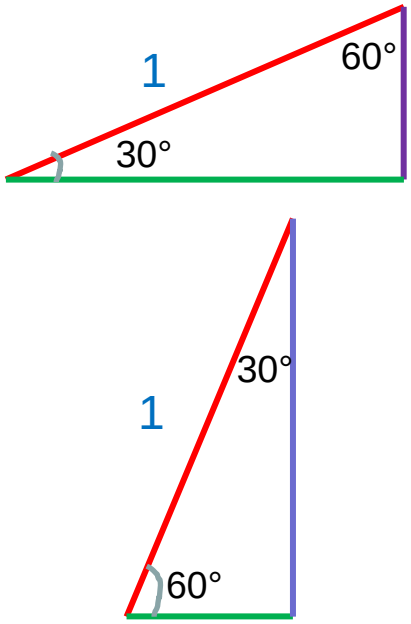


$$\text{sen } 30° = \frac{1}{2}$$

$$\cos 30° = \frac{\sqrt{3}}{2}$$

per angolo di 60° ???



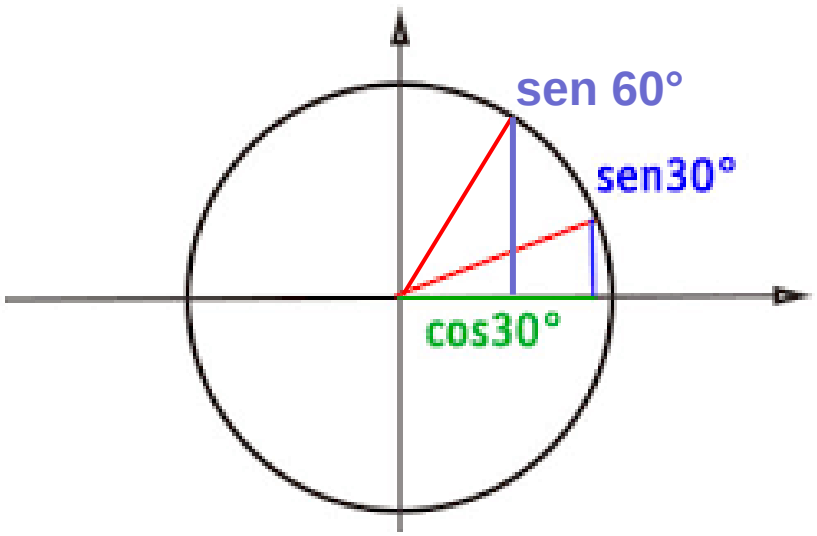


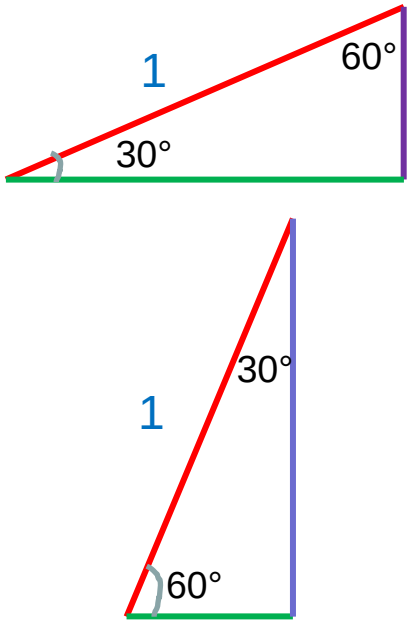
$\text{sen } 30° = \frac{1}{2}$

$\cos 30° = \frac{\sqrt{3}}{2}$

$\text{sen } 60° = \frac{\sqrt{3}}{2}$

$\cos 60° = \frac{1}{2}$





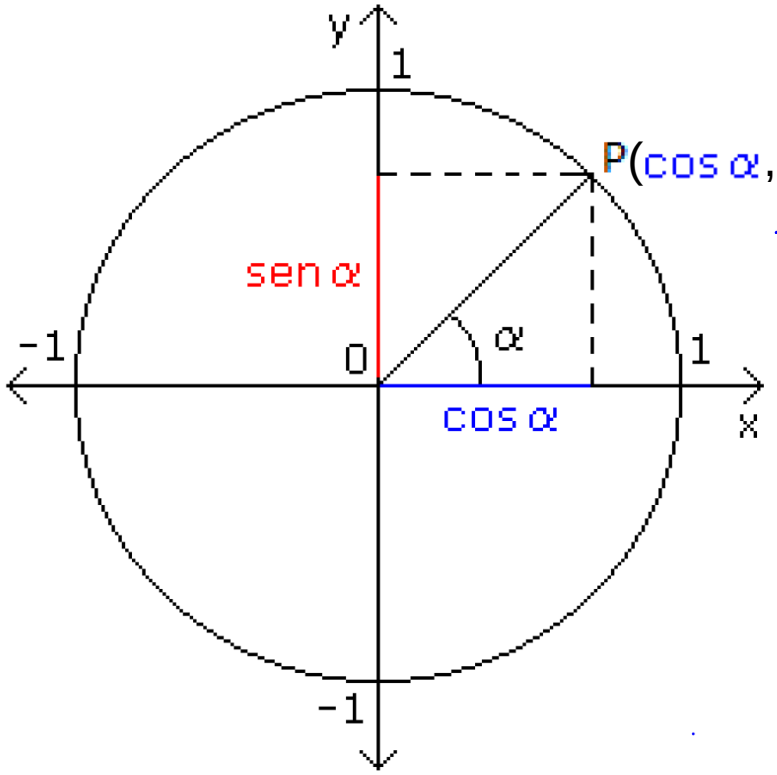
$$\text{sen } 30° = \frac{1}{2}$$

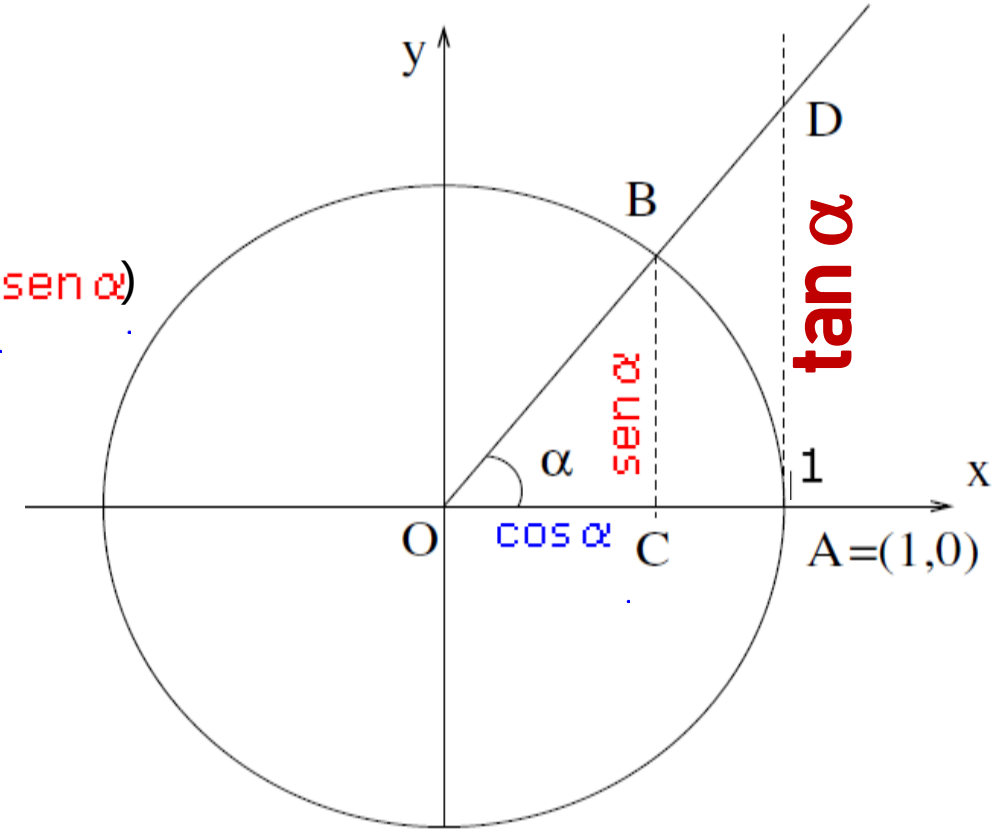
$$\cos 30° = \frac{\sqrt{3}}{2}$$

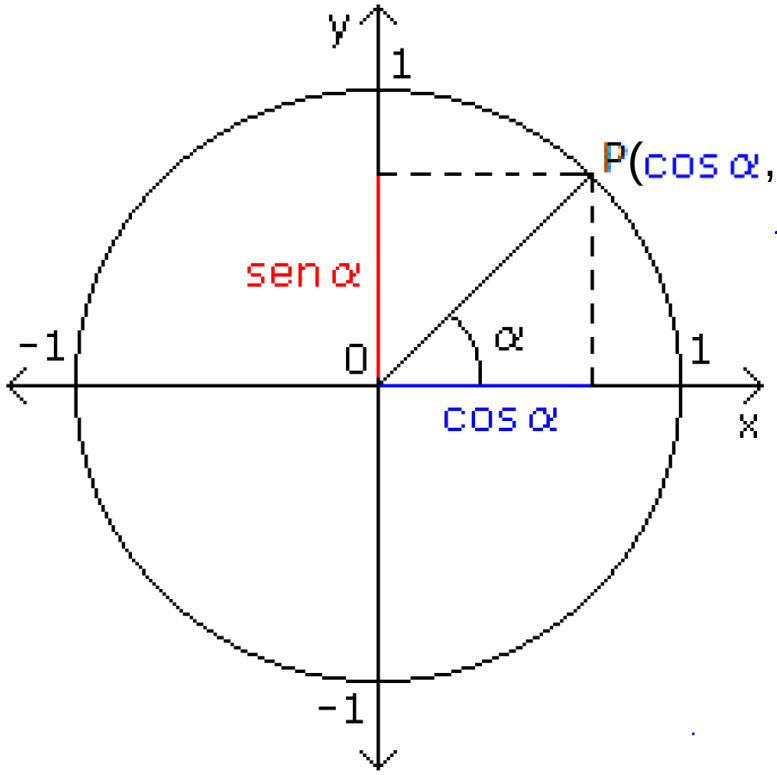
$$\text{sen } 60° = \frac{\sqrt{3}}{2}$$

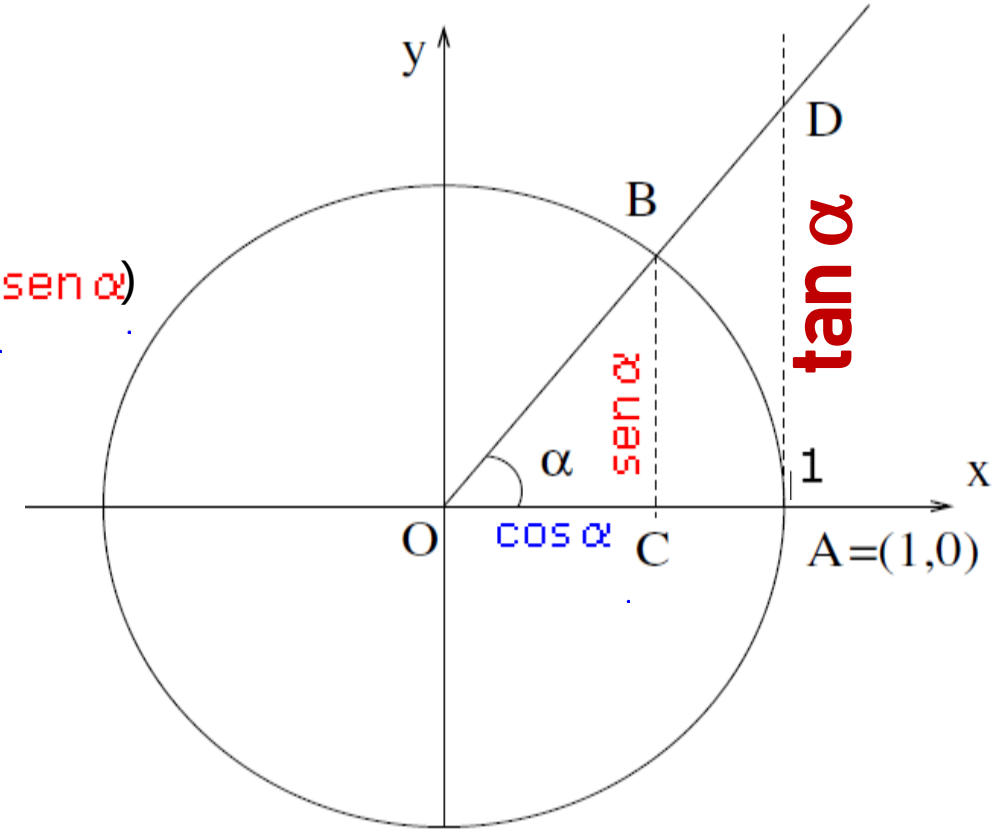
$$\cos 60° = \frac{1}{2}$$

1.732 /2 = 0.866

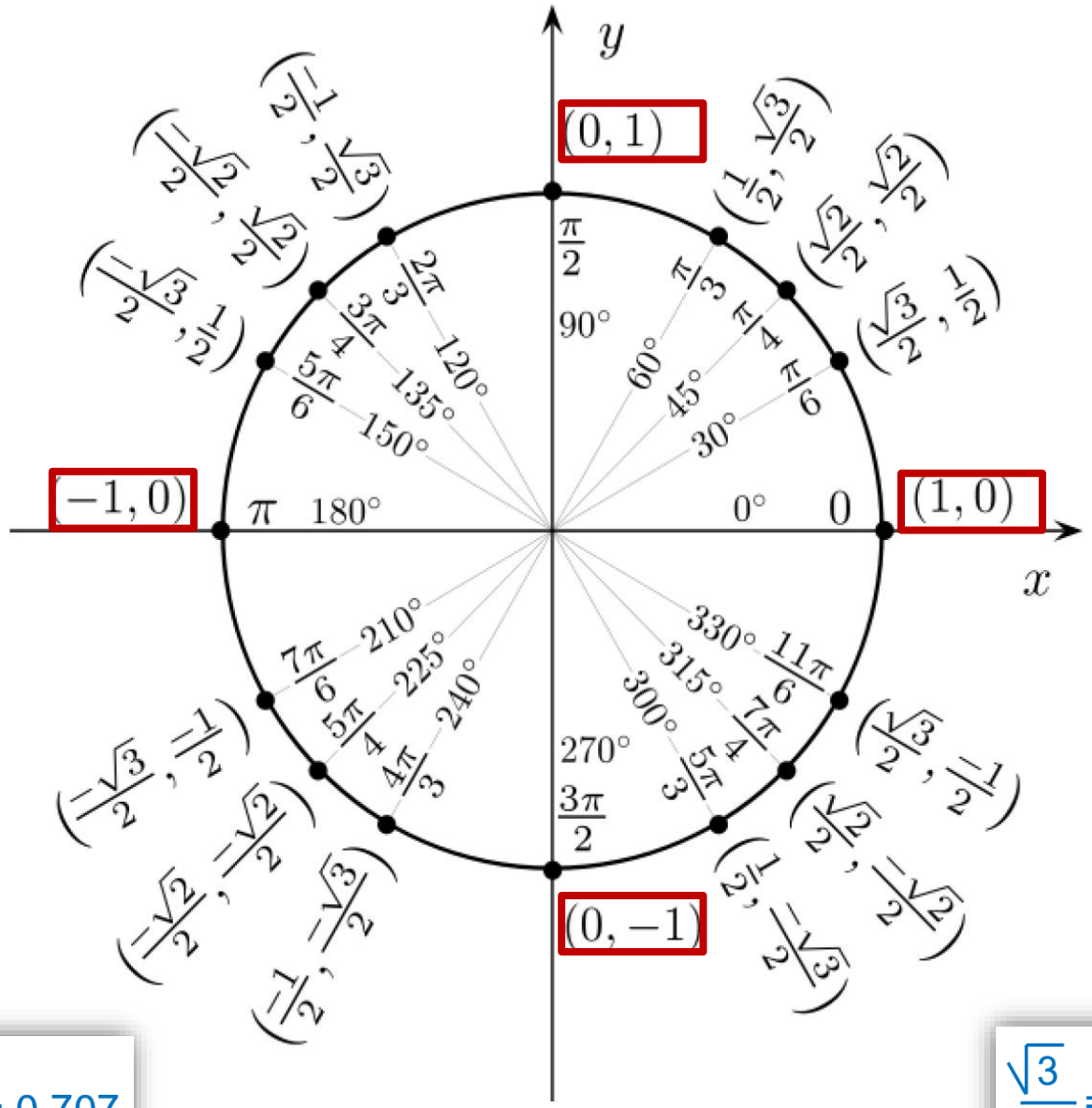

y
1
P(cos α,sen α)
sen α
-1
0
α
1
cos α
x
-1


y
D
B
tan α
sen α
α
1
x
O
cos α
C
A=(1,0)





$$\tan\alpha = \frac{\operatorname{sen}\alpha}{\cos\alpha} = \frac{CB}{OC} = \frac{AD}{OA} = AD$$



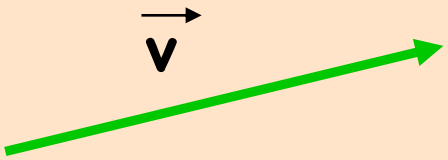
$\frac{\sqrt{2}}{2} = \frac{1.414}{2} = 0.707$

$\frac{\sqrt{3}}{2} = \frac{1.732}{2} = 0.866$

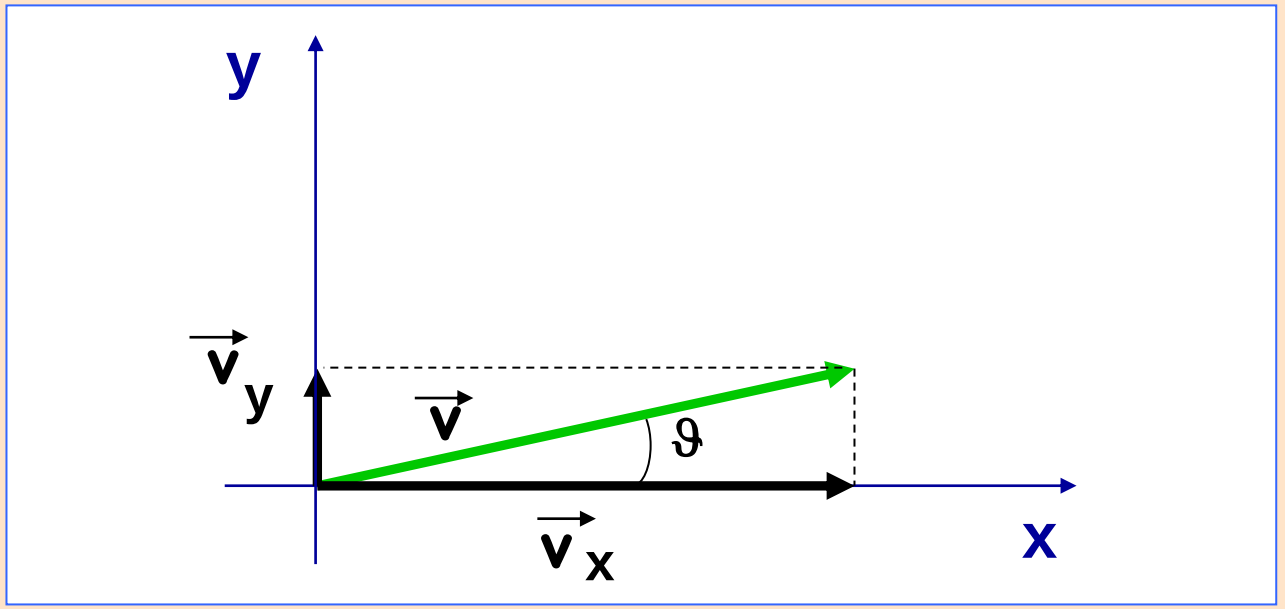
$\alpha =$	0°	30°	45°	60°	90°	180°	270°	360°
sen α								
cos α								

$\alpha =$	0°	30°	45°	60°	90°	180°	270°	360°
sen α								
cos α								

$\alpha =$	0°	30°	45°	60°	90°	180°	270°	360°
sen α	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	0	-1	0
cos α	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	-1	0	1



$$\vec{v} = \vec{v}_x + \vec{v}_y$$



$$v_x = v \cos \vartheta$$

$$v_y = v \operatorname{sen} \vartheta$$

$$v = \sqrt{v_x^2 + v_y^2}$$

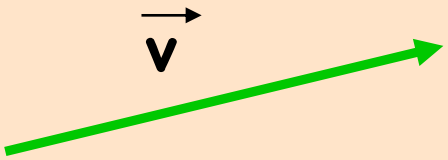
Esempio

$v = 10, \vartheta = 30°$

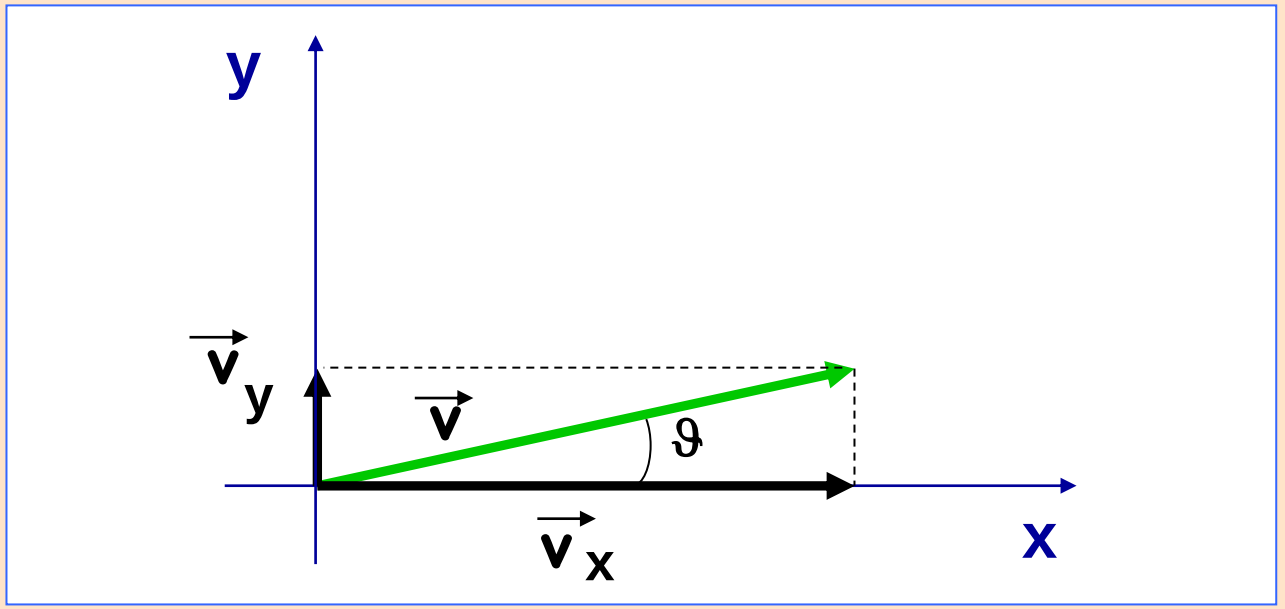
trovare v_x e v_y

$v_x =$

$v_y =$



$$\vec{v} = \vec{v}_x + \vec{v}_y$$



$$v_x = v \cos \vartheta$$

$$v_y = v \operatorname{sen} \vartheta$$

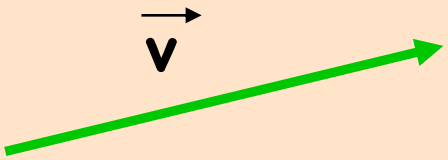
$$v = \sqrt{v_x^2 + v_y^2}$$

Esempio

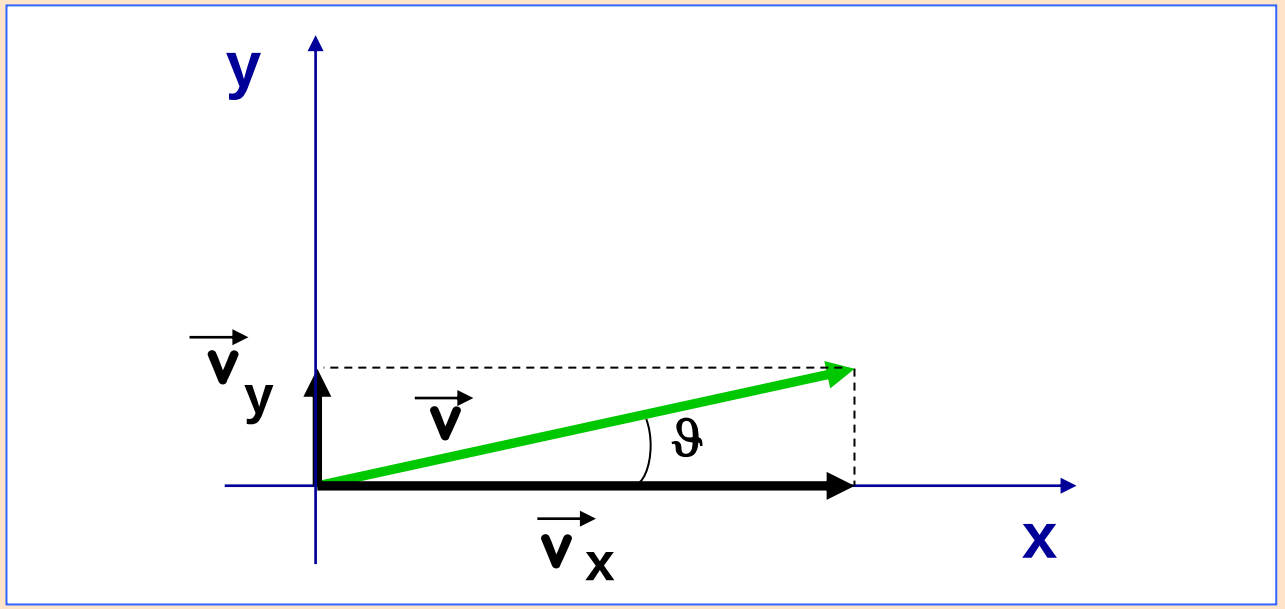
$v = 10, \vartheta = 30°$

$v_x = 10 \cos 30° = 8.66$

$v_y = 10 \operatorname{sen} 30° = 5$



$\vec{v} = \vec{v}_x + \vec{v}_y$



$v_x = v \cos \vartheta$

$v_y = v \operatorname{sen} \vartheta$

$v = \sqrt{v_x^2 + v_y^2}$

Esempio

$v = 10, \vartheta = 30°$

$v_x = 10 \cos 30° = 8.66$

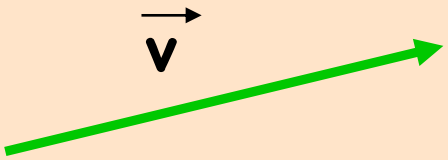
$v_y = 10 \operatorname{sen} 30° = 5$

Esempio

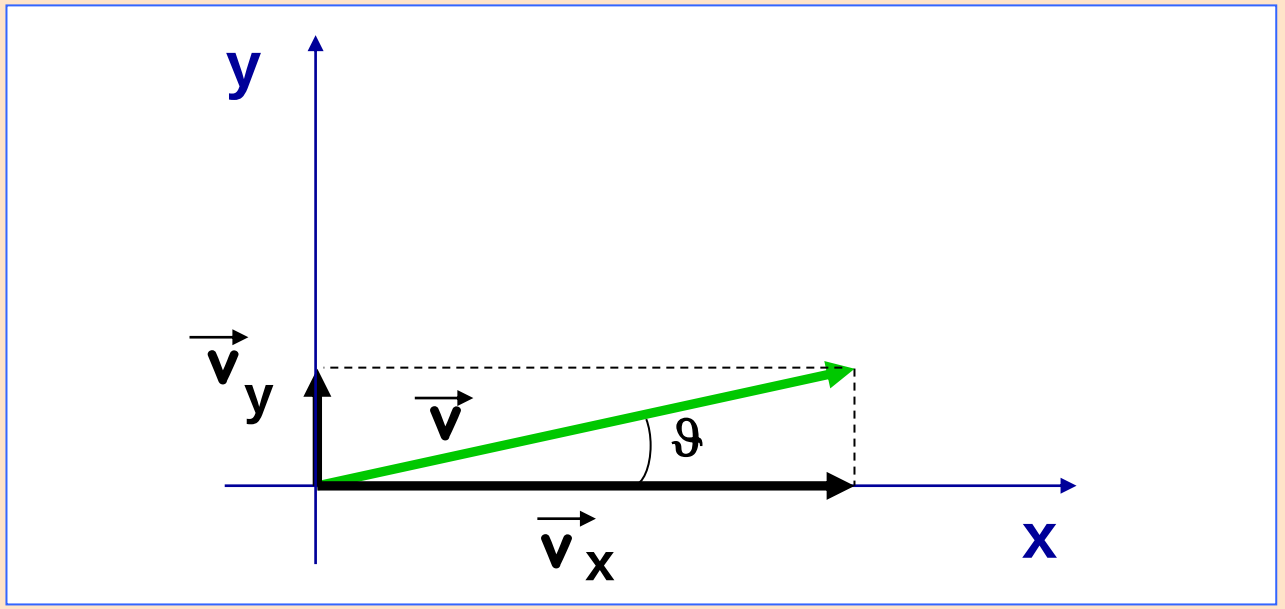
$v = 8, \quad \vartheta = 45°$

$v_x =$

$v_y =$



$$\vec{v} = \vec{v}_x + \vec{v}_y$$



$$v_x = v \cos \vartheta$$

$$v_y = v \operatorname{sen} \vartheta$$

$$v = \sqrt{v_x^2 + v_y^2}$$

Esempio

$v = 10, \vartheta = 30°$

$v_x = 10 \cos 30° = 8.66$

$v_y = 10 \operatorname{sen} 30° = 5$

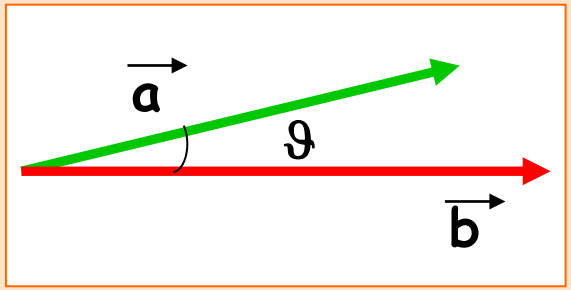
Esempio

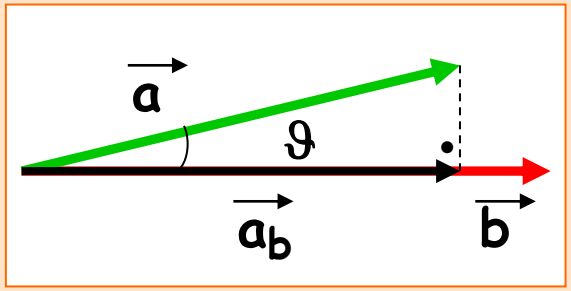
$v = 8, \quad \vartheta = 45°$

$v_x = 8 \cos 45° = 5.65$

$v_y = 8 \operatorname{sen} 45° = 5.65$

PRODOTTO SCALARE

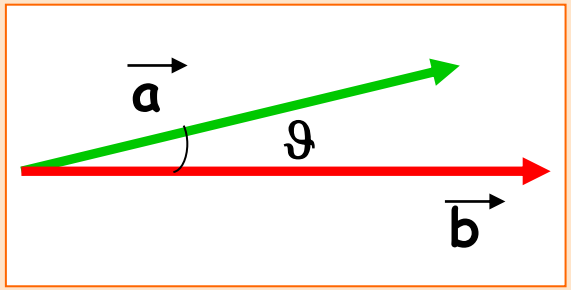


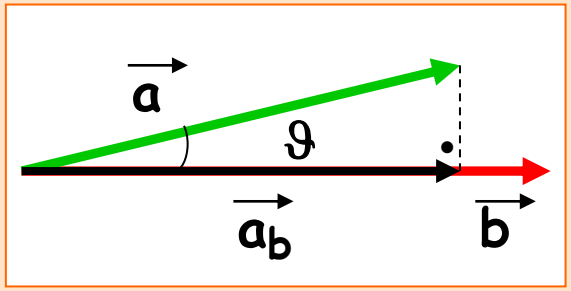


$\vec{a}_b$ è il vettore componente di $\vec{a}$ lungo la direzione di $\vec{b}$

$$\vec{a} \cdot \vec{b} = a_b\, b = a\, b \cos \vartheta$$

PRODOTTO SCALARE





$\vec{a}_b$ è il vettore componente di $\vec{a}$ lungo la direzione di $\vec{b}$

$$\vec{a} \cdot \vec{b} = a_b\, b = a\, b \cos \vartheta$$

PRODOTTO SCALARE

$$\vec{a} \cdot \vec{b} = a_b\, b = a\, b \cos \vartheta$$

Per $\vartheta = 0°$ — $\cos 0° = 1$

$$\vec{a} \cdot \vec{b} = a\, b$$

Per $\vartheta = 90°$ — $\cos 90° = 0$

$$\vec{a} \cdot \vec{b} = 0$$

Per $\vartheta = 180°$ — $\cos 180° = -1$

$$\vec{a} \cdot \vec{b} = -\, a\, b$$

PRODOTTO SCALARE

$$\vec{a} \cdot \vec{b} = a_b\, b = a\, b \cos \vartheta$$

Esempio $a = 10,\ b = 12,\ \vartheta = 45°$

$\vec{a} \cdot \vec{b} = a\ b \cos 45° = 120 \times 0.7 = 84$

Per $\vartheta = 0°$

$\vec{a} \cdot \vec{b} = a\ b$

Per $\vartheta = 90°$

$\vec{a} \cdot \vec{b} = 0$

Per $\vartheta = 180°$

$\vec{a} \cdot \vec{b} = -\ a\ b$

PRODOTTO SCALARE

$$\vec{a} \cdot \vec{b} = a_b\, b = a\, b \cos \vartheta$$

Esempio $a = 10,\ b = 12,\ \vartheta = 45°$

$\vec{a} \cdot \vec{b} = a\ b \cos 45° = 120 \times 0.7 = 84$

Esempio $a = 5,\ b = 7,\ \vartheta = 30°$

$\vec{a} \cdot \vec{b} =$? ? ? ? ? ?

Per $\vartheta = 0°$

$\vec{a} \cdot \vec{b} = a\ b$

Per $\vartheta = 90°$

$\vec{a} \cdot \vec{b} = 0$

Per $\vartheta = 180°$

$\vec{a} \cdot \vec{b} = -\ a\ b$

PRODOTTO SCALARE

$$\vec{a} \cdot \vec{b} = a_b\, b = a\, b \cos \vartheta$$

Esempio $a = 10,\ b = 12,\ \vartheta = 45°$

$\vec{a} \cdot \vec{b} = a\ b \cos 45° = 120 \times 0.7 = 84$

Esempio $a = 5,\ b = 7,\ \vartheta = 30°$

$\vec{a} \cdot \vec{b} = a\ b \cos 30° = 35 \times 0.86 = 30.1$

Per $\vartheta = 0°$

$\vec{a} \cdot \vec{b} = a\ b$

Per $\vartheta = 90°$

$\vec{a} \cdot \vec{b} = 0$

Per $\vartheta = 180°$

$\vec{a} \cdot \vec{b} = -\ a\ b$

PRODOTTO SCALARE

$$\vec{a} \cdot \vec{b} = a_b\, b = a\, b \cos \vartheta$$

Esempio $a = 10,\ b = 12,\ \vartheta = 45°$

$\vec{a} \cdot \vec{b} = a\ b \cos 45° = 120 \times 0.7 = 84$

Esempio $a = 5,\ b = 7,\ \vartheta = 30°$

$\vec{a} \cdot \vec{b} = a\ b \cos 30° = 35 \times 0.86 = 30.1$

Esempio $a = 3,\ b = 8,\ \vartheta = 60°$

$\vec{a} \cdot \vec{b} =$

Per $\vartheta = 0°$

$\vec{a} \cdot \vec{b} = a\ b$

Per $\vartheta = 90°$

$\vec{a} \cdot \vec{b} = 0$

Per $\vartheta = 180°$

$\vec{a} \cdot \vec{b} = -\ a\ b$

PRODOTTO SCALARE

$$\vec{a} \cdot \vec{b} = a_b\, b = a\, b \cos \vartheta$$

Esempio $a = 10,\ b = 12,\ \vartheta = 45°$

$\vec{a} \cdot \vec{b} = a\ b \cos 45° = 120 \times 0.7 = 84$

Esempio $a = 5,\ b = 7,\ \vartheta = 30°$

$\vec{a} \cdot \vec{b} = a\ b \cos 30° = 35 \times 0.86 = 30.1$

Esempio $a = 3,\ b = 8,\ \vartheta = 60°$

$\vec{a} \cdot \vec{b} = a\ b \cos 60° = 24 \times 0.5 = 12$

Per $\vartheta = 0°$

$\vec{a} \cdot \vec{b} = a\ b$

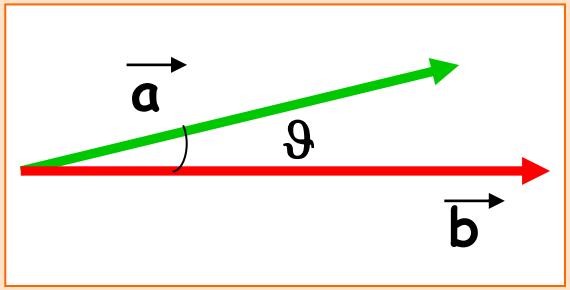
Per $\vartheta = 90°$

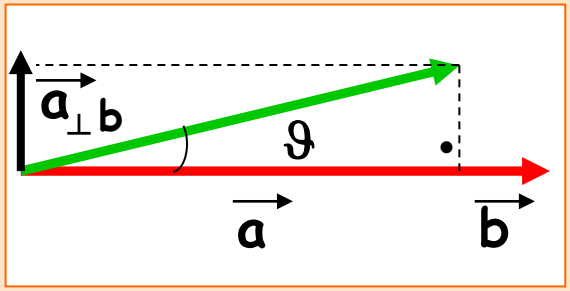
$\vec{a} \cdot \vec{b} = 0$

Per $\vartheta = 180°$

$\vec{a} \cdot \vec{b} = -\ a\ b$

PRODOTTO VETTORIALE





$\vec{a}_{\perp b}$ è il vettore componente di $\vec{a}$ perpendicolare alla direzione di $\vec{b}$

$$\vec{a} \times \vec{b} = \vec{c}$$

$\vec{c}$

$\vec{b}$

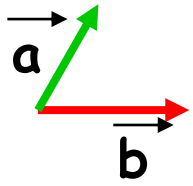
- **modulo** $c = a\ b\ \text{sen}\ \vartheta$
- **direzione** $\perp \vec{a}, \vec{b}$ — *direzione perpendicolare ai vettori* $\vec{a}$ *e* $\vec{b}$
- **verso** avvitamento (sovrapponendo **a** su **b**)

PRODOTTO VETTORIALE

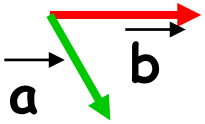
$$\vec{a} \times \vec{b} = \vec{c}$$

$\vec{c}$

- modulo $c = a\ b\ \text{sen}\ \vartheta$
- direzione $\perp \vec{a}, \vec{b}$
- verso avvitamento (sovrapponendo a su b)



$\vec{c}$ ha verso entrante ⊗



$\vec{c}$ ha verso uscente ⊙

verso entrante ⊗ **rotazione senso orario**

verso uscente ⊙ **rotazione senso antiorario**