NAVIGATION

Using the electronic calculator

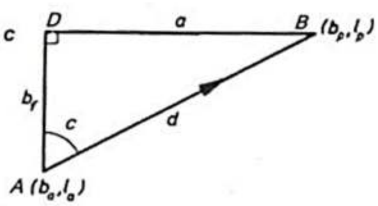
It is assumed that the calculator is using the prefixes plus (+) and minus (-) in all quadrants of the trigonometric functions. Therefore courses are given from 0° to 360°.

Prefix plus (+) shall be used for N latitude, N declination and East longitude.
Prefix minus (–) shall be used for S latitude, S declination and West longitude.

TERRESTRIAL NAVIGATION

Middle latitude sailing

$b_f = d \cos c$



$a = d \sin c$

$l_f = \dfrac{a}{\cos b_m}$

$a = l_f \cos b_m$

$\tan c = \dfrac{a}{b_f}$

$d = \dfrac{b_f}{\cos c} = \dfrac{a}{\sin c}$

$b_f = b_p - b_a$

$b_m = \dfrac{b_a + b_p}{2}$

$l_f = l_p - l_a$

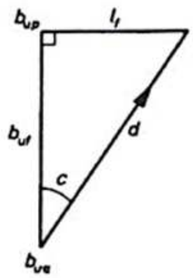
- b_f difference of latitude
- d distance
- c course 0° – 360°
- b_a latitude of departure
- b_p latitude of arrival
- a departure
- l_f difference of longitude
- b_m middle/mean latitude
- l_a longitude of departure
- l_p longitude of arrival

The prefixes (+ and -) of the formulas will give the direction of the sailing.

Mercator sailing

$$b^{\circ}_{ua} = b^{\circ}_{up} = \frac{180^{\circ}}{\pi} \ln \tan\left(45 + \frac{b}{2}\right)$$

b_{ua} extended departing latitude
b_{up} extended arriving latitude
b latitude of departure or arrival



The formulas give extended degrees of longitude (not minutes - ' -).

$$b'_{ua} = 60\, b^{\circ}_{ua}$$

Formula for conversion from extended degrees of longitude to extended minutes of longitude.

Both the unit degree or minutes may be used in the following formulas.

$$b_f = d \cos c$$

b_f difference of latitude
d distance
c course 0° – 360°

$$b_{uf} = b_{up} - b_{ua}$$

b_{uf} extended difference of latitude

$$l_f = b_{uf} \tan c$$

l_f difference of longitude

$$\tan c = \frac{l_f}{b_{uf}}$$

$$d = \frac{b_f}{\cos c}$$

Great circle sailings

$$\tan c = \frac{\sin l_f}{\tan b_p \ \cos b_a - \sin b_a \ \cos l_f}$$

c initial course

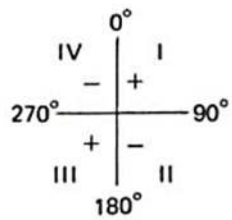
l_f difference of longitude

b_p latitude of arrival

b_a latitude of departure

The formulas can be used for all sailings. The answer will be given as quadrant course with a positive or negative prefix.

True course is given is accordance with this prefix rule, which is identical for N and S latitude.



True course is identical to c when the sailing is eastward, and (360° – c) when the sailing is westward.

$$\cos d = \sin b_a \sin b_p + \cos b_a \cos b_p \cos l_f$$

$$\cos c = \frac{\sin b_p - \sin b_a \cos d}{\cos b_a \sin d}$$

d distance

The formula may be used when the distance is known.

$$d_{1°} = \frac{60}{\tan (b_a + 0{,}2\, v \cos c) \sin c}$$

$d_{1°}$ distance to 1° change of course

b_a latitude of departure

(b_a + 0.2 v cos c) is equivalent to middle latitude for 24 hours sailing.

v ship's speed in knots
c initial course 0° – 360°

$$h_{1°} = \frac{60}{v \tan (b_a + 0{,}2\, v \cos c) \sin c}$$

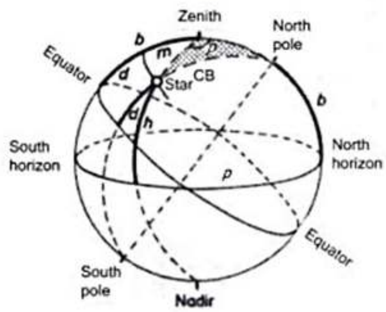
$h_{1°}$ hours to 1° change of course

The formulas can be used for all sailings except when the middle latitude is 0°.

CELESTIAL NAVIGATION

The altitude formula

$$\sin h = \sin b \sin d + \cos b \cos d \cos t$$



- *h* altitude of celestial body
- *b* observer's latitude
- *d* declination of celestial body
- *t* local hour angle of celestial body west from 0° to 360°.
- *CB* celestial body

The formulas may also be used for meridian altitudes.

Altitude azimuth

$$\cos p = \frac{\sin d - \sin b \sin h}{\cos b \cos h}$$

True bearing is equal to *p* when $180° < t < 360°$.

True bearing is equal to $(360° - p)$ when $0° < t < 180°$.

- *p* bearing of celestial body from N on both N and S latitude.
- *d* declination of celestial body
- *h* altitude of celestial body

The formula should be used in connection with the altitude formula.

Azimuth at sunrise and sunset

$$\cos p = \frac{\sin d}{\cos b}$$

A special case of the altitude-azimuth formula when $h = 0°$.

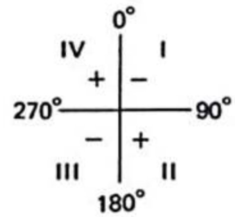
Time azimuth

$$\tan p_k = \frac{\sin t}{\tan d \cos b - \sin b \cos t}$$

- p_k quadrant bearing of celestial body
- *t* local celestial hour angle west from 0° to 360°.
- *b* observer's latitude
- *d* declination of celestial body

The formula is used when establishing the deviation of the compass.

True bearing is derived from this rule of prefix, which is identical for N and S latitude



The answer is given as quadrant bearing with positive or negative prefix.

Unidentified star

$$\sin d = \sin b \sin h + \cos b \cos h \cos p_r$$

- d declination of star if d becomes negative, the declination is S
- h true altitude of star (celestial body)
- p_r about true bearing of star given from 0° to 360°

Interval to noon

$$I_h = \frac{t_\emptyset}{15 + \frac{v \sin c}{60 \cos b_a}}$$

- I_h interval to true noon
- $t_\emptyset$ local east hour angle in degrees
- v ship's speed in knots
- c ship's course from 0° to 360°
- b_a latitude of departure