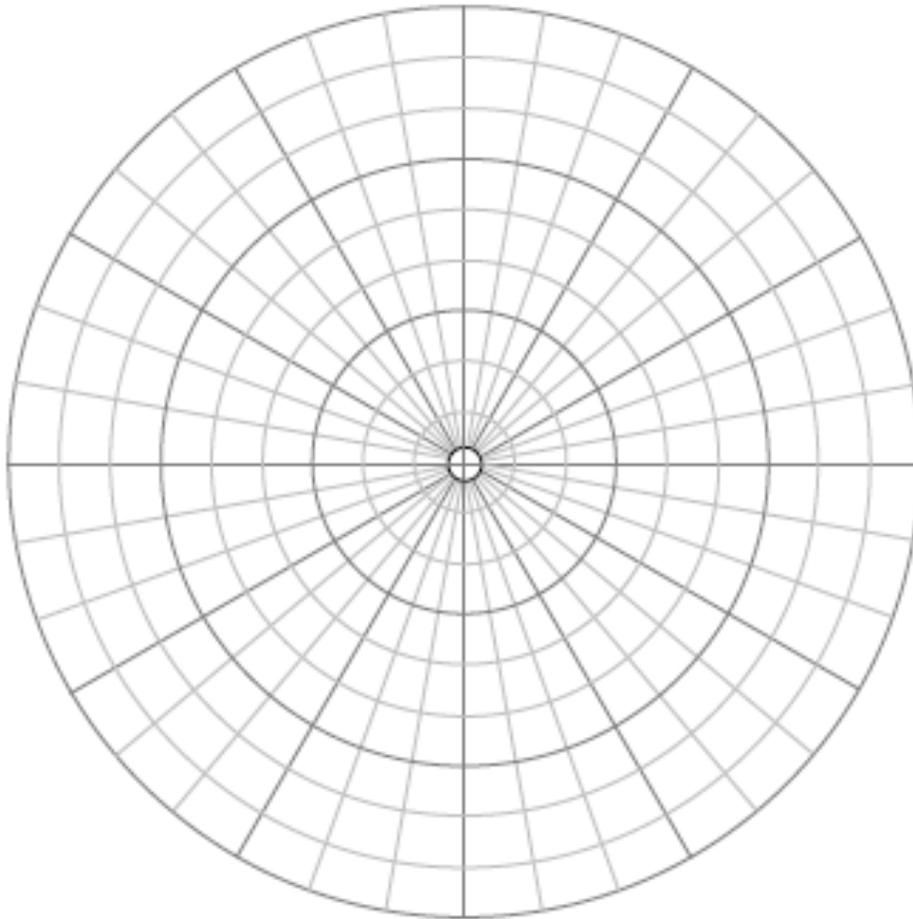


## Polar Graph Paper



[Waterproof Paper.com](http://WaterproofPaper.com)

Polar Coordinates  $(r, \theta)$   $r$  = radius, a distance that includes direction (positive or negative) from the origin

$\theta$  = angle, counterclockwise from polar axis.

1. Plot the following points:

$$A = (2, \pi/3) \quad B = (6, -\pi/6) \quad C = (5, 3\pi) \quad D = (-3, \pi/2)$$

$(r, \theta) = (r, \theta + 2\pi n)$  The point lands in the same place when you add/subtract a full rotation.

$(-r, \theta) = (r, \theta + \pi)$  A negative  $r$  results in a reflection over the origin, (the opposite direction). A positive  $r$  and  $\theta + \pi$  give a point in the same location.

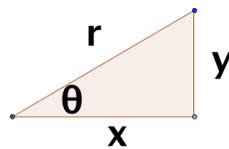
Rectangular coordinates  $(x,y)$  relate to polar coordinates  $(r, \theta)$  as follows:

$$x = r \cos \theta$$

$$y = r \sin \theta$$

$$\tan \theta = \frac{y}{x}$$

$$r^2 = x^2 + y^2$$



Convert the rectangular coordinate into polar form.

2.  $(-4,2)$

3.  $(1,1)$

4.  $(3,0)$

Convert the points to rectangular form:

5.  $(2, \pi/6)$

6.  $(-2, -\frac{5\pi}{4})$

Rewrite #3 as two other equivalent polar coordinates.

## Battleship -- Polar Coordinates Game

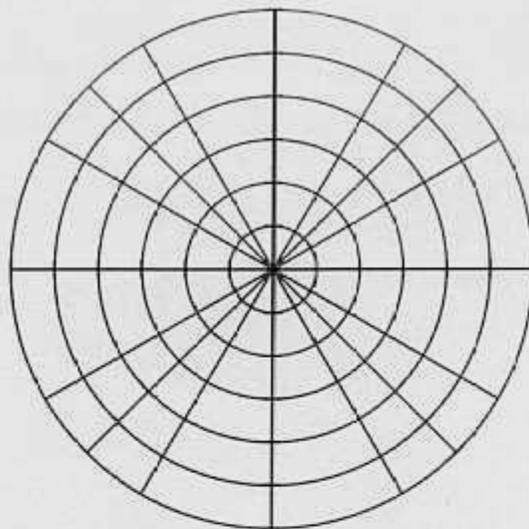
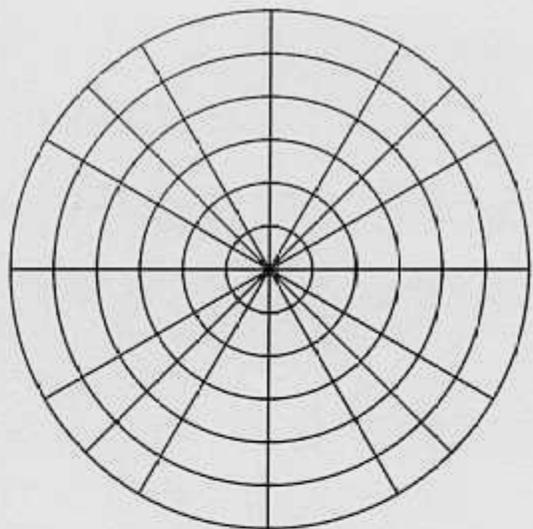
The first player to find and sink all their opponent's ships wins.

1. Carefully hiding their paper from their opponent's view, each player draws **five ships** on the left grid of their sheet (avoiding the origin). The ships are of sizes 5, 4, 3, 3 and 2, each with equally spaced coordinates according to its size. Each ship lies either entirely on a spoke radiating from the center or entirely on one of the six concentric circles shown. Spokes with reference angles of  $15^\circ$  and  $75^\circ$  should be drawn in as needed.
2. The players take turns directing shots at their opponent's ships. Each player is given four shots  $(r, \theta)$  on each turn. **The four shots must have signed radius and angle values as follows:  $(+, +)$ ,  $(-, +)$ ,  $(+, -)$ , and  $(-, -)$ .** A player who violates this rule forfeits the rest of the turn.
3. Players should record their shots on the grid on the right as HITS (x) or MISSES (o) for further reference.
4. When every point on a ship has been hit, the player says, "You sank my battleship!"
5. Players alternate until one sinks the other's entire fleet.

From The Mathematics Teacher, February 1995

Name \_\_\_\_\_

Opponent's Name \_\_\_\_\_



Turn    (+, +)   (+, -)   (-, +)   (-, -)

Turn    (+, +)   (+, -)   (-, +)   (-, -)

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18
- 19
- 20

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18
- 19
- 20