Turtle Graphics

Version 9.2.0.6

July 3, 2026

Turtle graphics are available in two forms: traditional imperative turtle operations that draw into a fixed window, and functional turtle operations that consume and produce a turtle picture.

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1 Traditional Turtles

```
(require graphics/turtles)
```
package: htdp-lib

To use any of the turtle drawing functions, you first need to initialize the turtles by calling `(turtles #t)`.

```
(turtles on?) → void?
  on? : any/c
(turtles) → void?
```

Shows and hides the turtles window based on *on?*. If *on?* is not supplied, the state is toggled.

```
(move n) → void?
  n : real?
```

Moves the turtle *n* pixels without drawing.

```
(draw n) → void?
  n : real?
```

Moves the turtle *n* pixels and draws a line on the path.

```
(erase n) → void?
  n : real?
```

Moves the turtle *n* pixels and erase along the path.

```
(move-offset h v) → void?
  h : real?
  v : real?
(draw-offset h v) → void?
  h : real?
  v : real?
(erase-offset h v) → void?
  h : real?
  v : real?
```

Like `move`, `draw`, and `erase`, but using a horizontal and vertical offset from the turtle's current position.

```
(turn theta) → void?
  theta : real?
```

Turns the turtle *theta* degrees counter-clockwise.

```
(turn/radians theta) → void?
  theta : real?
```

Turns the turtle *theta* radians counter-clockwise.

```
(clear) → void?
```

Erases the turtles window.

```
(home) → void?
```

Leaves only one turtle, in the start position.

```
(split expr ...)
```

Spawns a new turtle where the turtle is currently located. In order to distinguish the two turtles, only the new one evaluates *expr*. For example, if you start with a fresh turtle-window and evaluate:

```
(split (turn/radians (/ pi 2)))
```

you will have two turtles, pointing at right angles to each other. Continue with

```
(draw 100)
```

You will see two lines. Now, if you evaluate those two expression again, you will have four turtles, etc.

```
(split* expr ...)
```

Like `(split expr ...)`, except that one turtle is created for each *expr*.

For example, to create two turtles, one pointing at $\pi/2$ and one at $\pi/3$, evaluate

```
(split* (turn/radians (/ pi 3)) (turn/radians (/ pi 2)))
```

```
(tprompt expr ...)
```

Limits the splitting of the turtles. Before *expr* is evaluated, the state of the turtles (how many, their positions and headings) is "checkpointed." Then *expr* is evaluated, and then the state of the turtles is restored, but all drawing that may have occurred during execution of *expr* remains.

For example

```
(tprompt (draw 100))
```

moves a turtle forward 100 pixel while drawing a line, and then moves the turtle be immediately back to its original position. Similarly,

```
(tprompt (split (turn/radians (/ pi 2))))
```

splits the turtle into two, rotates one 90 degrees, and then collapses back to a single turtle.

The fern functions below demonstrate more advanced use of `tprompt`.

```
(save-turtle-bitmap name kind) → void?
  name : (or/c path-string? output-port?)
  kind : (or/c 'png 'jpeg 'xbm 'xpm 'bmp)
```

Saves the current state of the turtles window in an image file.

```
turtle-window-size : exact-positive-integer?
```

The size of the turtles window.

1.1 Examples

```
(require graphics/turtle-examples)
```
package: `htdp-lib`

The `graphics/turtle-examples` library's source is meant to be read, but it also exports the following examples. To display these examples, first initialize the turtle window with `(turtles #t)`.

```
(regular-poly sides radius) → void?
  sides : exact-nonnegative-integer?
  radius : real?
```

Draws a regular poly centered at the turtle with *sides* sides and with radius *radius*.

```
(regular-polys n s) → void?
  n : exact-nonnegative-integer?
  s : any/c
```

Draws *n* regular polys each with *n* sides centered at the turtle.

```
(radial-turtles n) → void?
  n : exact-nonnegative-integer?
```

Places 2^n turtles spaced evenly pointing radially outward.

```
(spaced-turtles n) → void?
  n : exact-nonnegative-integer?
```

Places 2^n turtles evenly spaced in a line and pointing in the same direction as the original turtle.

```
(spokes) → void?
```

Draws some spokes, using `radial-turtles` and `spaced-turtles`.

```
(gapped-lines) → void?
```

Draw a bunch of parallel line segments, using `spaced-turtles`.

```
(spyro-gyra) → void?
```

Draws a spyrograph-reminiscent shape.

```
(neato) → void?
```

As the name says...

```
(graphics-bexam) → void?
```

Draws a fractal that came up on an exam given at Rice in 1997 or so.

```
sierp-size : real?
```

A constant that is a good size for the `sierp` procedures.

```
(sierp sierp-size) → void?
  sierp-size : real?
(sierp-nosplit sierp-size) → void?
  sierp-size : real?
```

Draws the Sierpinski triangle in two different ways, the first using `split` heavily. After running the first one, try executing `(draw 10)`.

```
koch-size : real?
```

A constant that is a good size for the `koch` procedures.

```
(koch-split koch-size) → void?
  koch-size : real?
(koch-draw koch-size) → void?
  koch-size : real?
```

Draws the same Koch snowflake in two different ways.

```
(lorenz a b c) → void?
  a : real?
  b : real?
  c : real?
```

Watch the Lorenz attractor (a.k.a. butterfly attractor) initial values `a`, `b`, and `c`.

```
(lorenz1) → void?
```

Calls `lorenz` with good initial values.

```
(peano peano-size) → void?
  peano-size : real?
```

Draws the Peano space-filling curve.

```
(peano-position-turtle) → void?
```

Moves the turtle to a good place to prepare for a call to `peano`.

```
peano-size : exact-nonnegative-integer?
```

One size to use with `peano`.

```
fern-size : exact-nonnegative-integer?
```

A good size for the `fern1` and `fern2` functions.

```
(fern1 fern-size) → void?
  fern-size : exact-nonnegative-integer?
(fern2 fern-size) → void?
  fern-size : exact-nonnegative-integer?
```

Draws a fern fractal.

For `fern1`, you will probably want to point the turtle up before running this one, with something like:

```
(turn/radians (- (/ pi 2)))
```

For `fern2`, you may need to backup a little.

2 Value Turtles

```
(require graphics/value-turtles)
```
package: htdp-lib

The value turtles are a variation on traditional turtles. Rather than having just a single window where each operation changes the state of that window, in the graphics/value-turtles library, the entire turtles window is treated as a value. This means that each of the primitive operations accepts, in addition to the usual arguments, a turtles-window value; instead of returning nothing, each returns a turtles-window value.

```
(turtles  width
          height
         [init-x
          init-y
          init-angle]) → turtles?
  width : real?
  height : real?
  init-x : real? = (/ width 2)
  init-y : real? = (/ height 2)
  init-angle : real? = 0
```

Creates a new turtles window with the given *width* and *height*. The remaining arguments specify position of the initial turtle and the direction in radians (where 0 is to the right). The turtle's pen width is 1.

```
(turtles? v) → boolean?
  v : any/c
```

Determines if *v* is a turtles drawing.

```
(move n turtles) → turtles?
  n : real?
  turtles : turtles?
```

Moves the turtle *n* pixels, returning a new turtles window.

```
(draw n turtles) → turtles?
  n : real?
  turtles : turtles?
```

Moves the turtle *n* pixels and draws a line along the path, returning a new turtles window.

```
(turn theta turtles) → turtles?
  theta : real?
  turtles : turtles?
```

Turns the turtle *theta* degrees counter-clockwise, returning a new turtles window.

```
(turn/radians theta turtles) → turtles?
  theta : real?
  turtles : turtles?
```

Turns the turtle *theta* radians counter-clockwise, returning a new turtles window.

```
(set-pen-width turtles width) → turtles?
  turtles : turtles?
  width : (real-in 0 255)
```

Creates a new turtles that draws with the pen width *width*.

Added in version 1.5 of package `htdp-lib`.

```
(set-pen-color turtles color) → turtles?
  turtles : turtles?
  color : (or/c string? (is-a?/c color%))
```

Creates a new turtles that draws with the pen color *color*.

Added in version 1.6 of package `htdp-lib`.

```
(merge turtles1 turtles2) → turtles?
  turtles1 : turtles?
  turtles2 : turtles?
```

The `split` and `tprompt` forms provided by `graphics/turtles` aren't needed for `graphics/value-turtles`, since the turtles window is a value.

Instead, the `merge` accepts two turtles windows and combines the state of the two turtles windows into a single window. The new window contains all of the turtles of the previous two windows, but only the line drawings of the first turtles argument.

```
(clean turtles) → turtles?
  turtles : turtles?
```

Produces a turtles with the drawing as in *turtles*, but with zero turtles.

```
(turtles-width turtles) → (and/c real? positive?)
  turtles : turtles?
```

Returns the width of *turtles*.

```
(turtles-height turtles) → (and/c real? positive?)
  turtles : turtles?
```

Returns the height of *turtles*.

```
(turtles-pen-width turtles) → (real-in 0 255)
  turtles : turtles?
```

Returns the current width of the pen that the turtles use to draw.

Added in version 1.5 of package `htdp-lib`.

```
(turtles-pen-color turtles) → (is-a?/c color%)
  turtles : turtles?
```

Returns the current color of the pen that the turtles use to draw.

Added in version 1.6 of package `htdp-lib`.

```
(turtle-state turtles) → (listof (vector/c real? real? real?
                                           #:immutable? #t
                                           #:flat? #t))
  turtles : turtles?
```

Returns the position and heading of all of the turtles; the first element in each vector is the *x* coordinate, the second is the *y* coordinate and the third is the angle in degrees.

Added in version 1.5 of package `htdp-lib`.

```
(restore-turtle-state turtles state) → turtles?
  turtles : turtles?
  state : (listof (vector/c real? real? real?
                            #:immutable? #t
                            #:flat? #t))
```

Keeps the drawing as in *turtles*, but puts the turtles positions and headings as specified in *state*.

Added in version 1.5 of package `htdp-lib`.

```
(turtles-pict turtles) → pict?
  turtles : turtles?
```

Constructs a pict that draws the same way that *turtles* would draw, except that it does not draw the frame around the turtles, nor does it draw the turtles themselves. Additionally, the

size of the resulting is not the size of *turtles*, but instead sized exactly to the the lines that that are in the drawing in *turtles*.

Added in version 1.5 of package htdp-lib.

2.1 Examples

```
(require graphics/value-turtles-examples)
```
package: htdp-lib

The graphics/turtle-examples library's source is meant to be read, but it also exports the following examples.

```
(radial-turtles n turtles) → turtles?
  n : exact-nonnegative-integer?
  turtles : turtles?
```

Places 2^n turtles spaced evenly pointing radially outward.

```
(spaced-turtles n turtles) → turtles?
  n : exact-nonnegative-integer?
  turtles : turtles?
```

Places 2^n turtles evenly spaced in a line and pointing in the same direction as the original turtle.

```
(neato turtles) → turtles?
  turtles : turtles?
```

As the name says...

```
(regular-poly sides radius turtles) → turtles?
  sides : exact-nonnegative-integer?
  radius : real?
  turtles : turtles?
```

Draws a regular poly centered at the turtle with *sides* sides and with radius *radius*.

```
(regular-polys n s turtles) → turtles?
  n : exact-nonnegative-integer?
  s : any/c
  turtles : turtles?
```

Draws *n* regular polys each with *n* sides centered at the turtle.

```
(spokes turtles) → turtles?
  turtles : turtles?
```

Draws some spokes, using `radial-turtles` and `spaced-turtles`.

```
(spyro-gyra turtles) → turtles?
  turtles : turtles?
```

Draws a spyrograph-reminiscent shape.