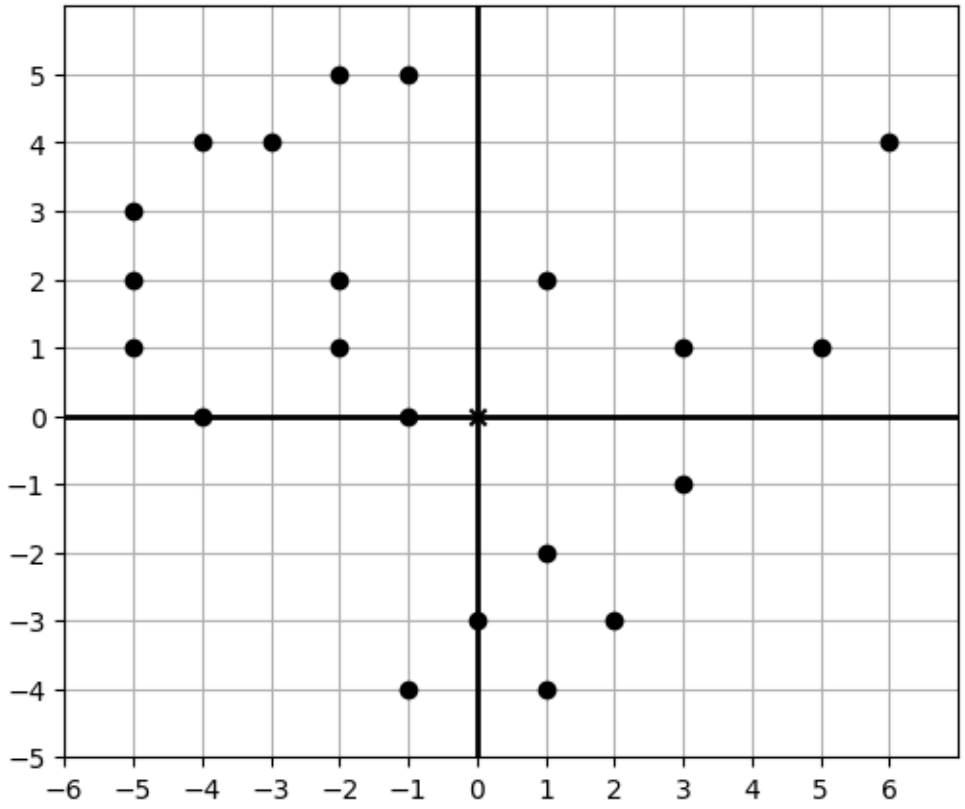
2.1.

September 1, 2025

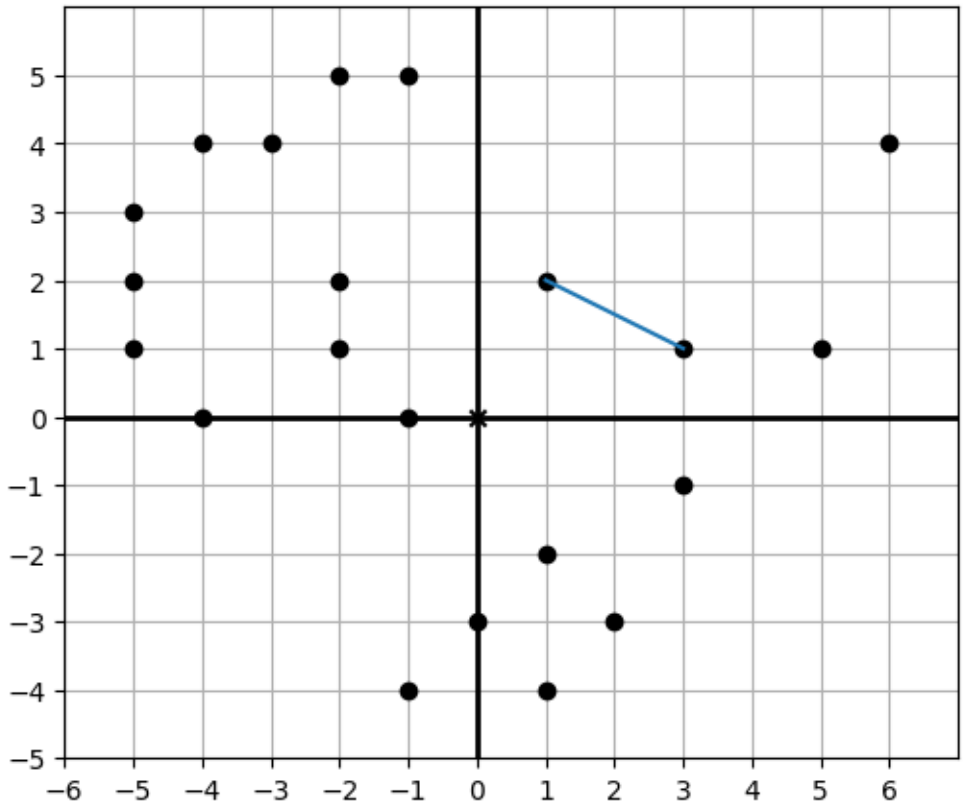
[2]:
```
import matplotlib
from vector_drawing import *
```

[3]:
```
dino_vectors = [(6,4), (3,1), (1,2), (-1,5), (-2,5), (-3,4), (-4,4),
    (-5,3), (-5,2), (-2,2), (-5,1), (-4,0), (-2,1), (-1,0), (0,-3),
    (-1,-4), (1,-4), (2,-3), (1,-2), (3,-1), (5,1)
]
draw(Points(*dino_vectors))
```

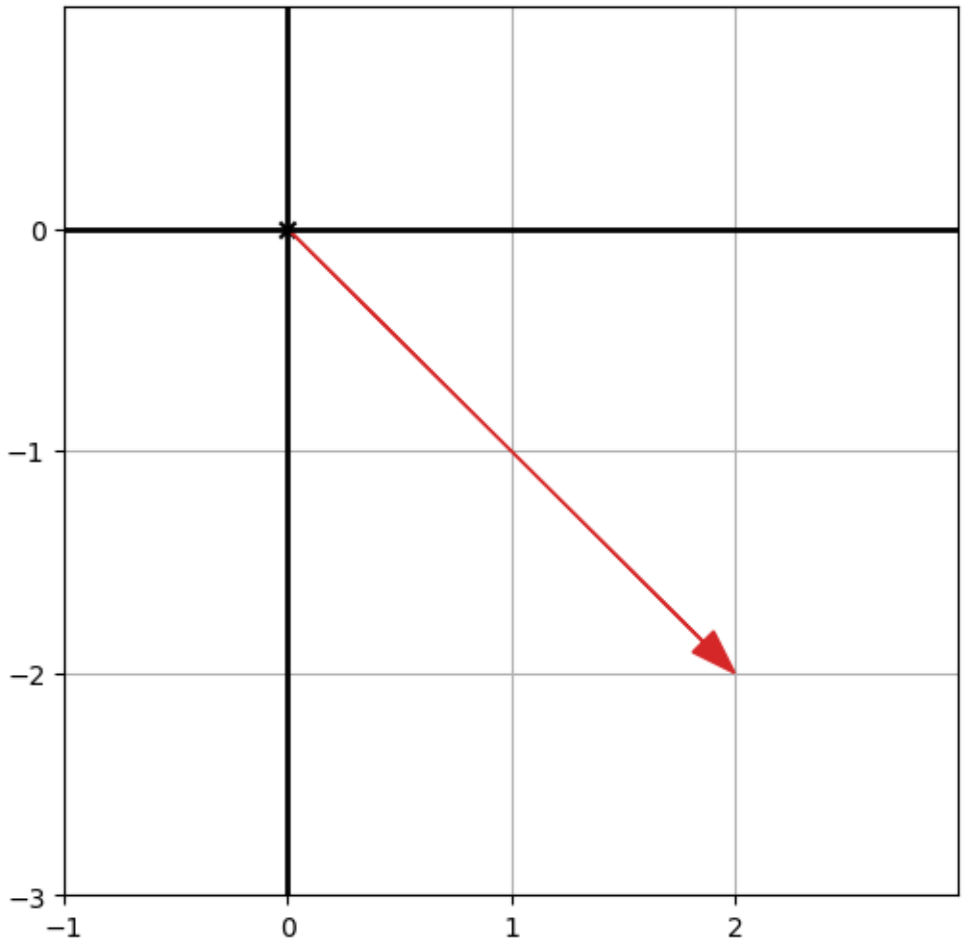


[7]:
```
draw(
    Points(*dino_vectors),
```

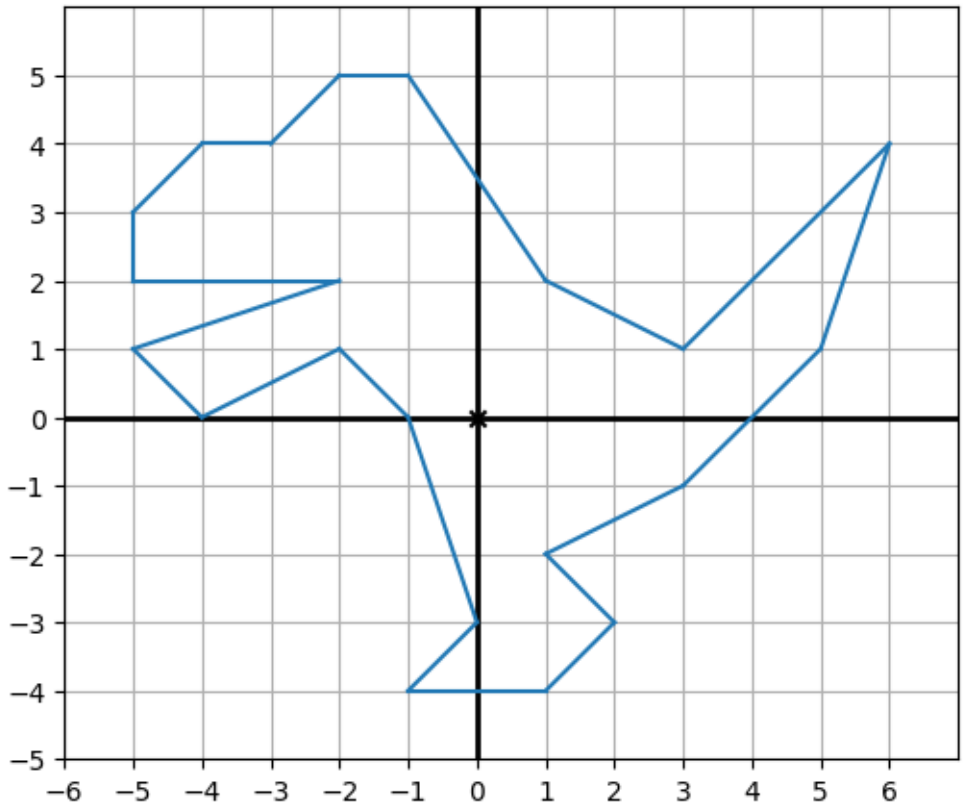
```
    Segment(dino_vectors[1], dino_vectors[2])
    )
```



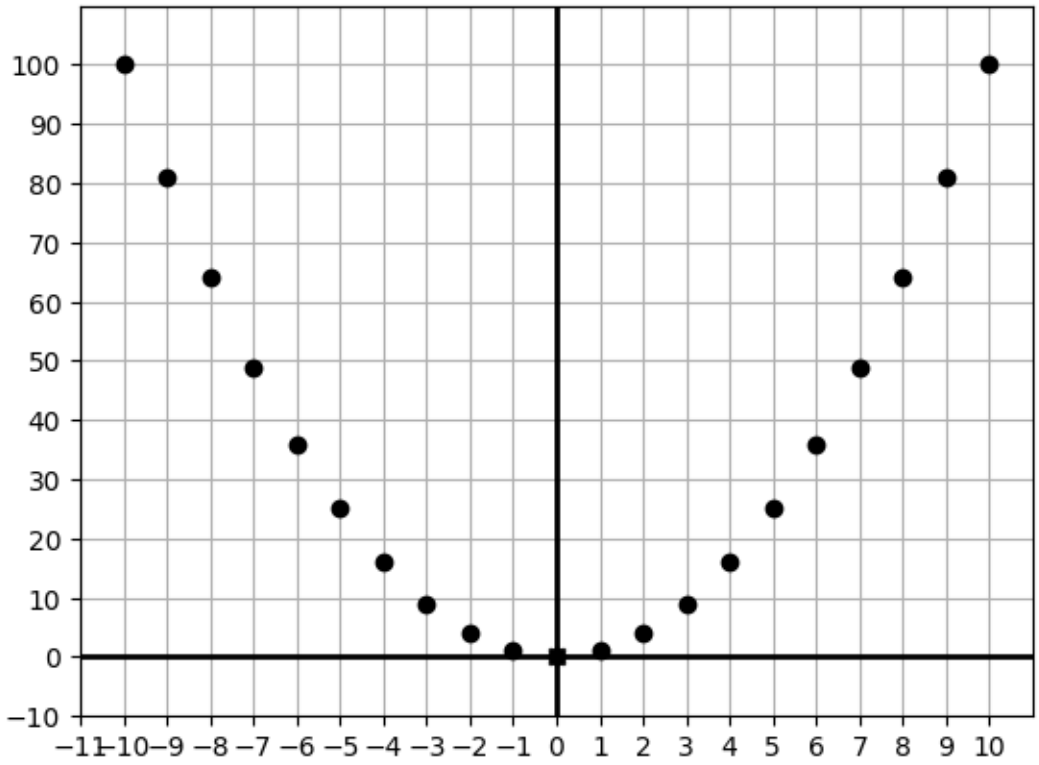
[ ]:
```
#  2.2:     (2, -2)
draw(Arrow((2, -2)))
```



[10]:
```
#  2.4    dino_vectors  Polygon
draw(Polygon(*dino_vectors))
```



[ ]:
```
#  2.5 x  -10 10     draw     (x, x**2)
draw(Points(*[(x, x**2) for x in range(-10, 11)])
    ,grid=(1,10)
    ,nice_aspect_ratio=False)

# grid  (1, 10)   1        10      nice_aspect_ratio   False  x y
```



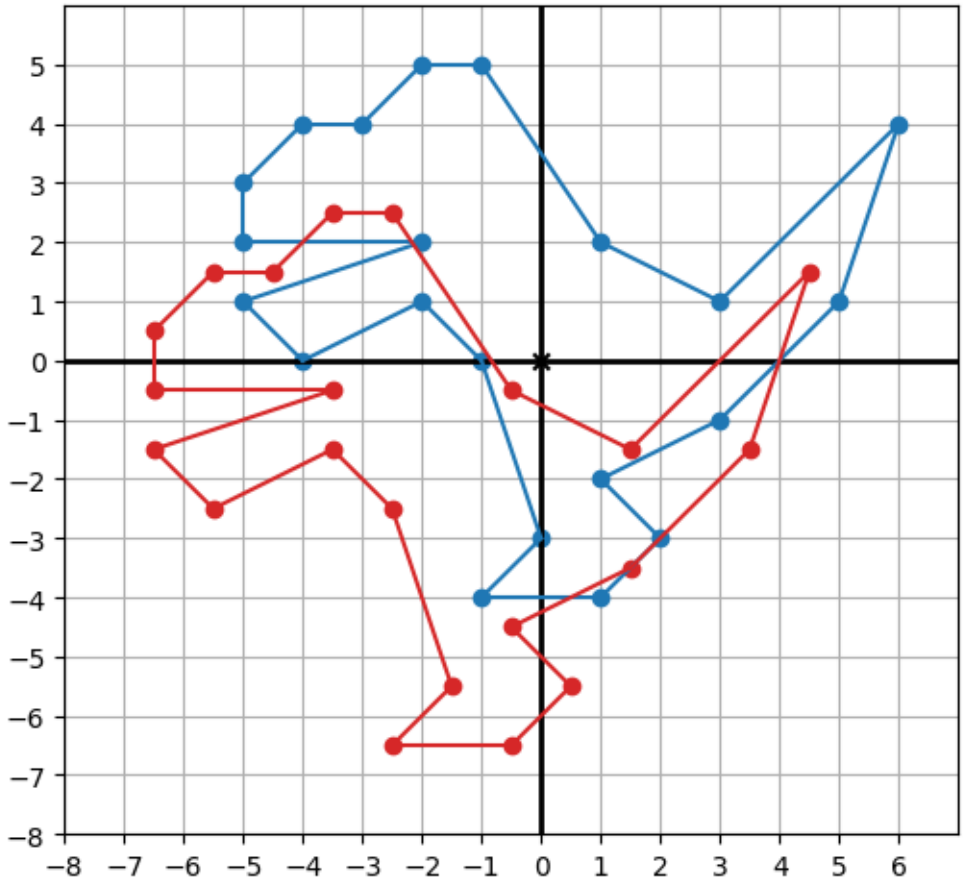
[16]:
```
from vectors import *
```

[20]:
```
dino_vectors2 = [add(x, (-1.5, -2.5)) for x in dino_vectors]
dino_vectors2
```

[20]:
```
[(4.5, 1.5),
 (1.5, -1.5),
 (-0.5, -0.5),
 (-2.5, 2.5),
 (-3.5, 2.5),
 (-4.5, 1.5),
 (-5.5, 1.5),
 (-6.5, 0.5),
 (-6.5, -0.5),
 (-3.5, -0.5),
 (-6.5, -1.5),
 (-5.5, -2.5),
 (-3.5, -1.5),
 (-2.5, -2.5),
 (-1.5, -5.5),
 (-2.5, -6.5),
 (-0.5, -6.5),
```

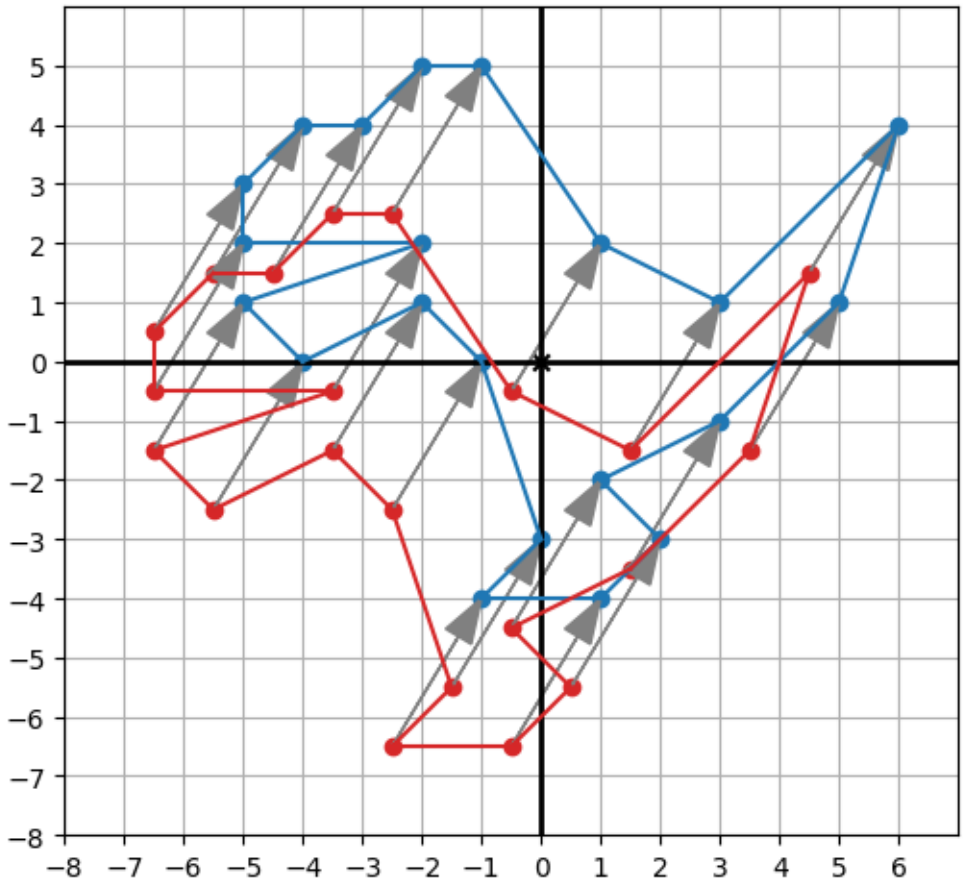
```
 (0.5, -5.5),
 (-0.5, -4.5),
 (1.5, -3.5),
 (3.5, -1.5)]
```

[19]:
```
draw(
    Points(*dino_vectors, color=blue),
    Polygon(*dino_vectors, color=blue),
    Points(*dino_vectors2, color=red),
    Polygon(*dino_vectors2, color=red)
)
```



[24]:
```
arrows = []
for i in range(len(dino_vectors)):
    arrows.append(Arrow(dino_vectors[i], dino_vectors2[i], color=gray))

draw(
    Points(*dino_vectors, color=blue),
```

```
    Polygon(*dino_vectors, color=blue),
    Points(*dino_vectors2, color=red),
    Polygon(*dino_vectors2, color=red),
    *arrows
)
```



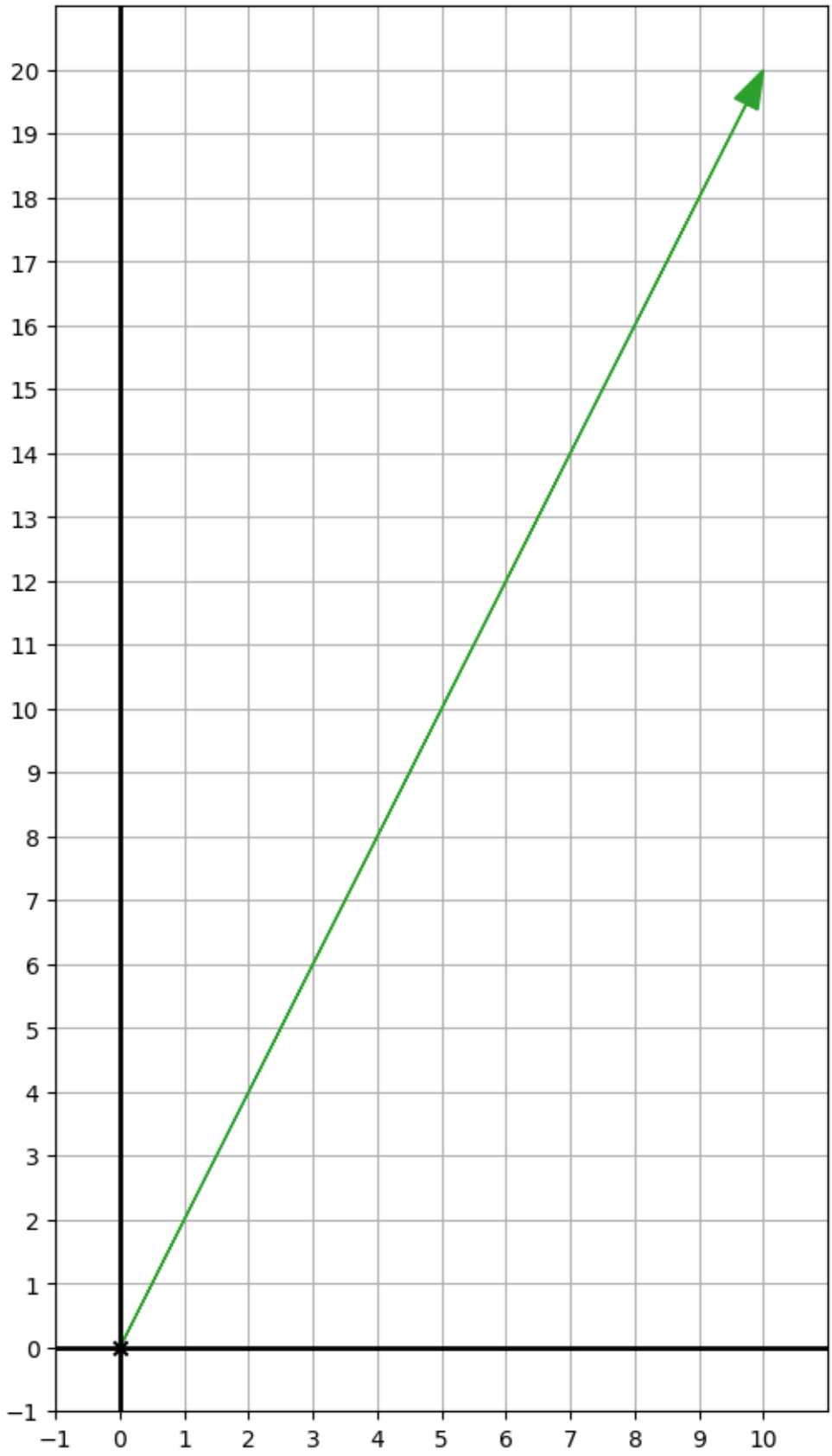
[25]:
```
#  2.6
u = (-2, 0)
v = (1.5, 1.5)
w = (4, 1)

print(add(u, v))
print(add(u, w))
print(add(v, w))
print(add(u, v, w))
```

```
(-0.5, 1.5)
(2, 1)
(5.5, 2.5)
```

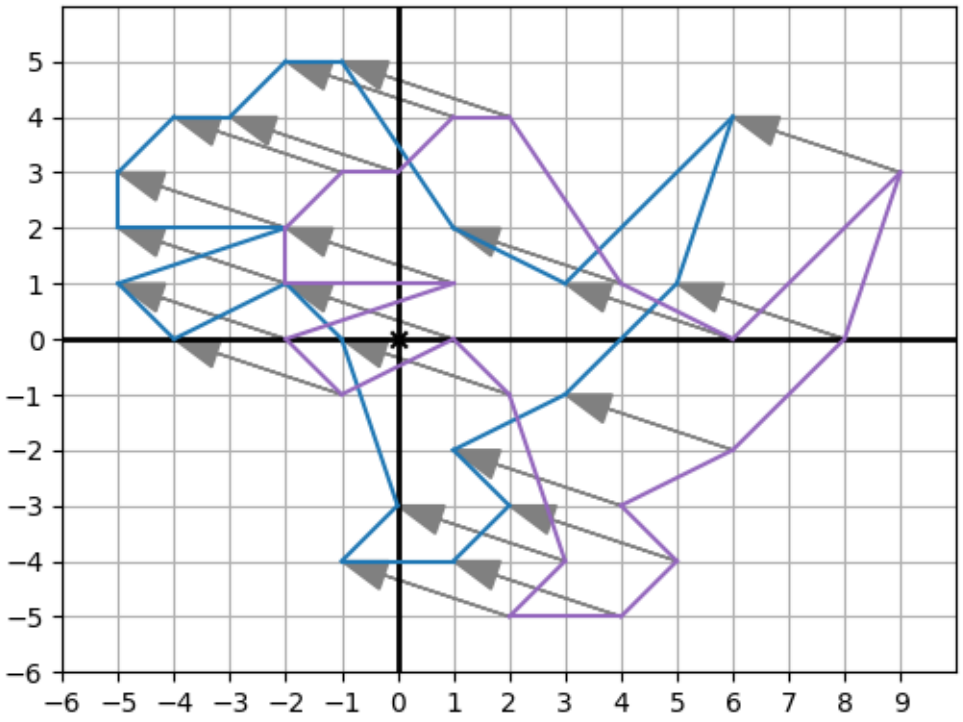
```
(3.5, 2.5)
```

[26]:
```
#  2.7
a = add((1,2), (2, 4), (3, 6), (4, 8))
print(a)
draw(Arrow(a, color=green))
```

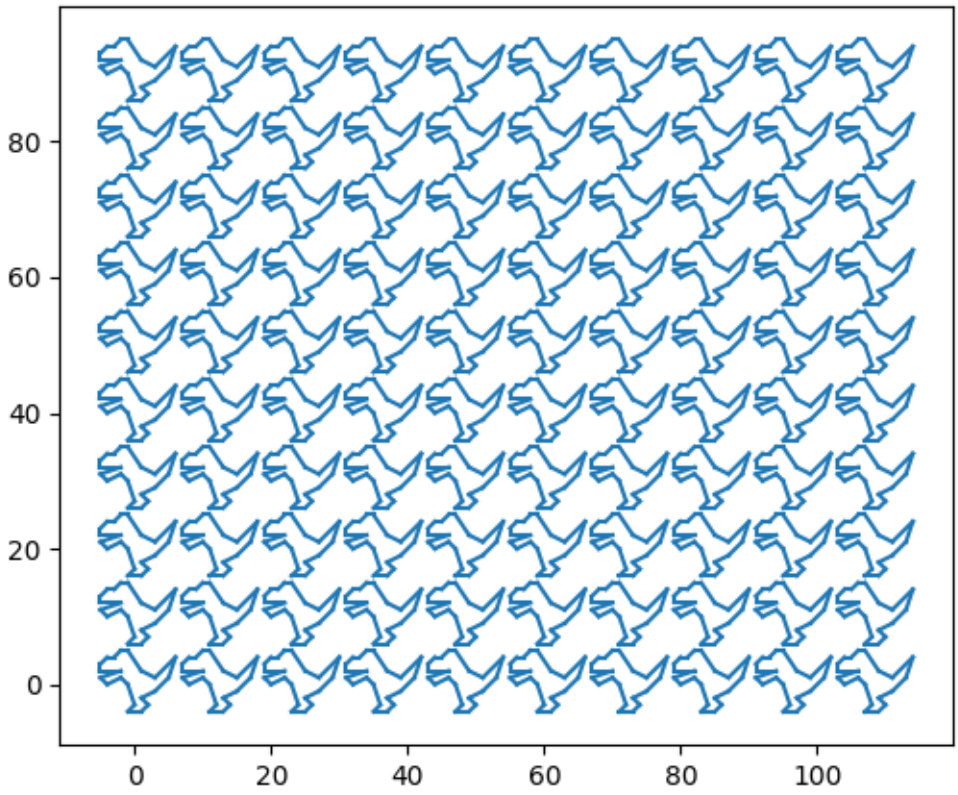
```
(10, 20)
```


20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
−1
−1
0
1
2
3
4
5
6
7
8
9
10

[30]:
```
#  2.8:   translate(translation, vectors)
def translate(translation, vectors):
    return [add(v, translation) for v in vectors]
draw(
    Polygon(*dino_vectors, color=blue),
    Polygon(*translate((3, -1), dino_vectors), color=purple),
    *[Arrow(dino_vectors[i], translate((3, -1), dino_vectors)[i], color=gray)␣
 ↪for i in range(len(dino_vectors))]
)
```



[33]:
```
#  2.11:       Python   100
polygons = []
for i in range(10):
    for j in range(10):
            polygons.append(Polygon(*translate((i*12, j*10), dino_vectors),␣
 ↪color=blue))
draw(*polygons, grid=None, axes=None, origin=None)
```



[ ]:
```
#  2.15: dino_vectors          length
m = max(dino_vectors, key=length)
print(m)
print(length(m))
```

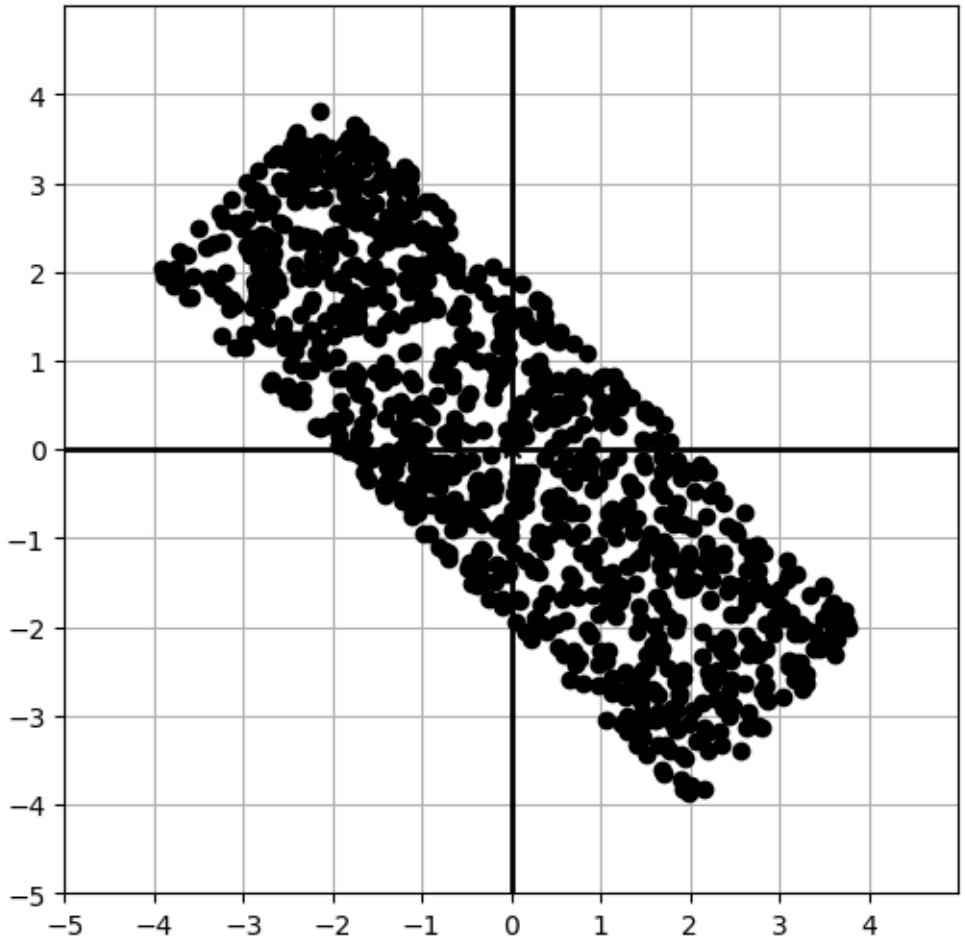
```
(6, 4)
7.211102550927978
```

[36]:
```
#  2.15 :
def absolute_length(v):
    return abs(v[0]) + abs(v[1])
m2 = max(dino_vectors, key=absolute_length)
print(m2)
print(absolute_length(m2))
```

```
(6, 4)
10
```

[39]:
```
#  2.19
from random import uniform
u = (-1,1)
v = (1,1)
```

```
def random_r():
    return uniform(-3,3)
def random_s():
    return uniform(-1,1)

possibilities = [add(scale(random_r(), u), scale(random_s(), v))
                 for i in range(0,1000)]
draw(
    Points(*possibilities)
)
```



[44]:
```
#  2.25:    Python perimeter(vectors)
def perimeter(vectors):
    return sum(distance(vectors[i], vectors[(i+1) % len(vectors)]) for i in␣
 ↪range(len(vectors)))

print(perimeter(dino_vectors))
```

```
print(perimeter(dino_vectors2))
print(perimeter([(0,1), (1,1), (1,0), (0,0)]))  #  1    4
```

```
44.77115093694563
44.77115093694563
4.0
```