

# Cultivating Complex Analysis: Meromorphic functions (5.2.4)

Jiří Lebl

Departemento pri Matematiko de Oklahoma Ŝtata Universitato

## Definition

A holomorphic function  $f: U \setminus S \rightarrow \mathbb{C}$  with poles on a discrete set  $S \subset U$  is said to be *meromorphic*.

## Definition

A holomorphic function  $f: U \setminus S \rightarrow \mathbb{C}$  with poles on a discrete set  $S \subset U$  is said to be *meromorphic*.

If  $p \in S$  is a pole, set  $f(p) = \infty$  to get a function

$$f: U \rightarrow \mathbb{C}_{\infty}.$$

## Definition

A holomorphic function  $f: U \setminus S \rightarrow \mathbb{C}$  with poles on a discrete set  $S \subset U$  is said to be *meromorphic*.

If  $p \in S$  is a pole, set  $f(p) = \infty$  to get a function

$$f: U \rightarrow \mathbb{C}_\infty.$$

The extended  $f$  is continuous.

## Definition

A holomorphic function  $f: U \setminus S \rightarrow \mathbb{C}$  with poles on a discrete set  $S \subset U$  is said to be *meromorphic*.

If  $p \in S$  is a pole, set  $f(p) = \infty$  to get a function

$$f: U \rightarrow \mathbb{C}_\infty.$$

The extended  $f$  is continuous.

In fact,  $1/f$  is holomorphic at a pole  $p$  (defn. of “ $f: U \rightarrow \mathbb{C}_\infty$  is holomorphic at  $p$ ”).

## Definition

A holomorphic function  $f: U \setminus S \rightarrow \mathbb{C}$  with poles on a discrete set  $S \subset U$  is said to be *meromorphic*.

If  $p \in S$  is a pole, set  $f(p) = \infty$  to get a function

$$f: U \rightarrow \mathbb{C}_\infty.$$

The extended  $f$  is continuous.

In fact,  $1/f$  is holomorphic at a pole  $p$  (defn. of " $f: U \rightarrow \mathbb{C}_\infty$  is holomorphic at  $p$ ").

A *meromorphic function* is "a holomorphic function  $f: U \rightarrow \mathbb{C}_\infty$ ."

## Definition

A holomorphic function  $f: U \setminus S \rightarrow \mathbb{C}$  with poles on a discrete set  $S \subset U$  is said to be *meromorphic*.

If  $p \in S$  is a pole, set  $f(p) = \infty$  to get a function

$$f: U \rightarrow \mathbb{C}_\infty.$$

The extended  $f$  is continuous.

In fact,  $1/f$  is holomorphic at a pole  $p$  (defn. of “ $f: U \rightarrow \mathbb{C}_\infty$  is holomorphic at  $p$ ”).

A *meromorphic function* is “a holomorphic function  $f: U \rightarrow \mathbb{C}_\infty$ .”

**Technicality:** Should we consider the constant  $\infty$  a meromorphic function?

## Definition

A holomorphic function  $f: U \setminus S \rightarrow \mathbb{C}$  with poles on a discrete set  $S \subset U$  is said to be *meromorphic*.

If  $p \in S$  is a pole, set  $f(p) = \infty$  to get a function

$$f: U \rightarrow \mathbb{C}_\infty.$$

The extended  $f$  is continuous.

In fact,  $1/f$  is holomorphic at a pole  $p$  (defn. of “ $f: U \rightarrow \mathbb{C}_\infty$  is holomorphic at  $p$ ”).

A *meromorphic function* is “a holomorphic function  $f: U \rightarrow \mathbb{C}_\infty$ .”

**Technicality:** Should we consider the constant  $\infty$  a meromorphic function?

In this course, we do not.



## Definition

A holomorphic function  $f: U \setminus S \rightarrow \mathbb{C}$  with poles on a discrete set  $S \subset U$  is said to be *meromorphic*.

If  $p \in S$  is a pole, set  $f(p) = \infty$  to get a function

$$f: U \rightarrow \mathbb{C}_\infty.$$

The extended  $f$  is continuous.

In fact,  $1/f$  is holomorphic at a pole  $p$  (defn. of “ $f: U \rightarrow \mathbb{C}_\infty$  is holomorphic at  $p$ ”).

A *meromorphic function* is “a holomorphic function  $f: U \rightarrow \mathbb{C}_\infty$ .”

**Technicality:** Should we consider the constant  $\infty$  a meromorphic function?

In this course, we do not.

To emphasize we will often say “Let  $f: U \rightarrow \mathbb{C}_\infty$  be meromorphic.”

One could define functions on  $U \subset \mathbb{C}_\infty$  (like we did with LFTs).

One could define functions on  $U \subset \mathbb{C}_\infty$  (like we did with LFTs).

If  $\infty \in U$ ,  $f: U \rightarrow \mathbb{C}_\infty$  is holomorphic at  $\infty$  if  $f(1/z)$  is holomorphic at 0.

One could define functions on  $U \subset \mathbb{C}_\infty$  (like we did with LFTs).

If  $\infty \in U$ ,  $f: U \rightarrow \mathbb{C}_\infty$  is holomorphic at  $\infty$  if  $f(1/z)$  is holomorphic at 0.

So an LFT is a biholomorphic mapping  $\mathbb{C}_\infty \rightarrow \mathbb{C}_\infty$ .

One could define functions on  $U \subset \mathbb{C}_\infty$  (like we did with LFTs).

If  $\infty \in U$ ,  $f: U \rightarrow \mathbb{C}_\infty$  is holomorphic at  $\infty$  if  $f(1/z)$  is holomorphic at 0.

So an LFT is a biholomorphic mapping  $\mathbb{C}_\infty \rightarrow \mathbb{C}_\infty$ .

**Exercise:** Show that a holomorphic  $f: \mathbb{C}_\infty \rightarrow \mathbb{C}_\infty$  has at most finitely many poles and finitely many zeros.

One could define functions on  $U \subset \mathbb{C}_\infty$  (like we did with LFTs).

If  $\infty \in U$ ,  $f: U \rightarrow \mathbb{C}_\infty$  is holomorphic at  $\infty$  if  $f(1/z)$  is holomorphic at 0.

So an LFT is a biholomorphic mapping  $\mathbb{C}_\infty \rightarrow \mathbb{C}_\infty$ .

**Exercise:** Show that a holomorphic  $f: \mathbb{C}_\infty \rightarrow \mathbb{C}_\infty$  has at most finitely many poles and finitely many zeros.

**Exercise:** Show that a holomorphic  $f: \mathbb{C}_\infty \rightarrow \mathbb{C}_\infty$  is either constant or onto.

One could define functions on  $U \subset \mathbb{C}_\infty$  (like we did with LFTs).

If  $\infty \in U$ ,  $f: U \rightarrow \mathbb{C}_\infty$  is holomorphic at  $\infty$  if  $f(1/z)$  is holomorphic at 0.

So an LFT is a biholomorphic mapping  $\mathbb{C}_\infty \rightarrow \mathbb{C}_\infty$ .

**Exercise:** Show that a holomorphic  $f: \mathbb{C}_\infty \rightarrow \mathbb{C}_\infty$  has at most finitely many poles and finitely many zeros.

**Exercise:** Show that a holomorphic  $f: \mathbb{C}_\infty \rightarrow \mathbb{C}_\infty$  is either constant or onto.

**Exercise:** Show that a holomorphic  $f: \mathbb{C}_\infty \rightarrow \mathbb{C}_\infty$  is a rational function (a polynomial divided by a polynomial).

One could define functions on  $U \subset \mathbb{C}_\infty$  (like we did with LFTs).

If  $\infty \in U$ ,  $f: U \rightarrow \mathbb{C}_\infty$  is holomorphic at  $\infty$  if  $f(1/z)$  is holomorphic at 0.

So an LFT is a biholomorphic mapping  $\mathbb{C}_\infty \rightarrow \mathbb{C}_\infty$ .

**Exercise:** Show that a holomorphic  $f: \mathbb{C}_\infty \rightarrow \mathbb{C}_\infty$  has at most finitely many poles and finitely many zeros.

**Exercise:** Show that a holomorphic  $f: \mathbb{C}_\infty \rightarrow \mathbb{C}_\infty$  is either constant or onto.

**Exercise:** Show that a holomorphic  $f: \mathbb{C}_\infty \rightarrow \mathbb{C}_\infty$  is a rational function (a polynomial divided by a polynomial).

**Exercise:** Show that an injective holomorphic  $f: \mathbb{C}_\infty \rightarrow \mathbb{C}_\infty$  is an LFT.