# Pokazatelji isplativosti ulaganja

## Financijska matematika, IPS

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# Sadržaj

# prvi zadatak

## Zadatak 1

*Investitoru su prezentirana dva projekta A i B s dobicima krajem godina danima u tablici. Pomoću NPV metode odaberite isplativiji projekt ako znamo da je cijena kapitala 8%.*

| *projekt* | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| *A* | −600 000 | 180 000 | 160 000 | 170 000 | 210 000 |
| *B* | −600 000 | 100 000 | 140 000 | 215 000 | 300 000 |

# Rješenje

| projekt | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| A | −600 000 | 180 000 | 160 000 | 170 000 | 210 000 |
| B | −600 000 | 100 000 | 140 000 | 215 000 | 300 000 |

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3} + \frac{F_4}{r^4}$$

## Rješenje

| projekt | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| A | −600 000 | 180 000 | 160 000 | 170 000 | 210 000 |
| B | −600 000 | 100 000 | 140 000 | 215 000 | 300 000 |

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3} + \frac{F_4}{r^4}$$

$$NPV(A) = -600\,000 + \frac{180\,000}{1.08} + \frac{160\,000}{1.08^2} + \frac{170\,000}{1.08^3} + \frac{210\,000}{1.08^4}$$

## Rješenje

| projekt | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| A | −600 000 | 180 000 | 160 000 | 170 000 | 210 000 |
| B | −600 000 | 100 000 | 140 000 | 215 000 | 300 000 |

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3} + \frac{F_4}{r^4}$$

$$NPV(A) = -600\,000 + \frac{180\,000}{1.08} + \frac{160\,000}{1.08^2} + \frac{170\,000}{1.08^3} + \frac{210\,000}{1.08^4}$$

$$NPV(A) = -6851.37$$

## Rješenje

| projekt | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| A | −600 000 | 180 000 | 160 000 | 170 000 | 210 000 |
| B | −600 000 | 100 000 | 140 000 | 215 000 | 300 000 |

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3} + \frac{F_4}{r^4}$$

$$NPV(A) = -600\,000 + \frac{180\,000}{1.08} + \frac{160\,000}{1.08^2} + \frac{170\,000}{1.08^3} + \frac{210\,000}{1.08^4}$$

$$NPV(A) = -6851.37$$

$$NPV(B) = -600\,000 + \frac{100\,000}{1.08} + \frac{140\,000}{1.08^2} + \frac{215\,000}{1.08^3} + \frac{300\,000}{1.08^4}$$

## Rješenje

| projekt | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| A | −600 000 | 180 000 | 160 000 | 170 000 | 210 000 |
| B | −600 000 | 100 000 | 140 000 | 215 000 | 300 000 |

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3} + \frac{F_4}{r^4}$$

$$NPV(A) = -600\,000 + \frac{180\,000}{1.08} + \frac{160\,000}{1.08^2} + \frac{170\,000}{1.08^3} + \frac{210\,000}{1.08^4}$$

$$NPV(A) = -6851.37$$

$$NPV(B) = -600\,000 + \frac{100\,000}{1.08} + \frac{140\,000}{1.08^2} + \frac{215\,000}{1.08^3} + \frac{300\,000}{1.08^4}$$

$$NPV(B) = 3802.92$$

## Rješenje

| projekt | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| A | $-600\,000$ | $180\,000$ | $160\,000$ | $170\,000$ | $210\,000$ |
| B | $-600\,000$ | $100\,000$ | $140\,000$ | $215\,000$ | $300\,000$ |

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3} + \frac{F_4}{r^4}$$

$$NPV(A) = -600\,000 + \frac{180\,000}{1.08} + \frac{160\,000}{1.08^2} + \frac{170\,000}{1.08^3} + \frac{210\,000}{1.08^4}$$

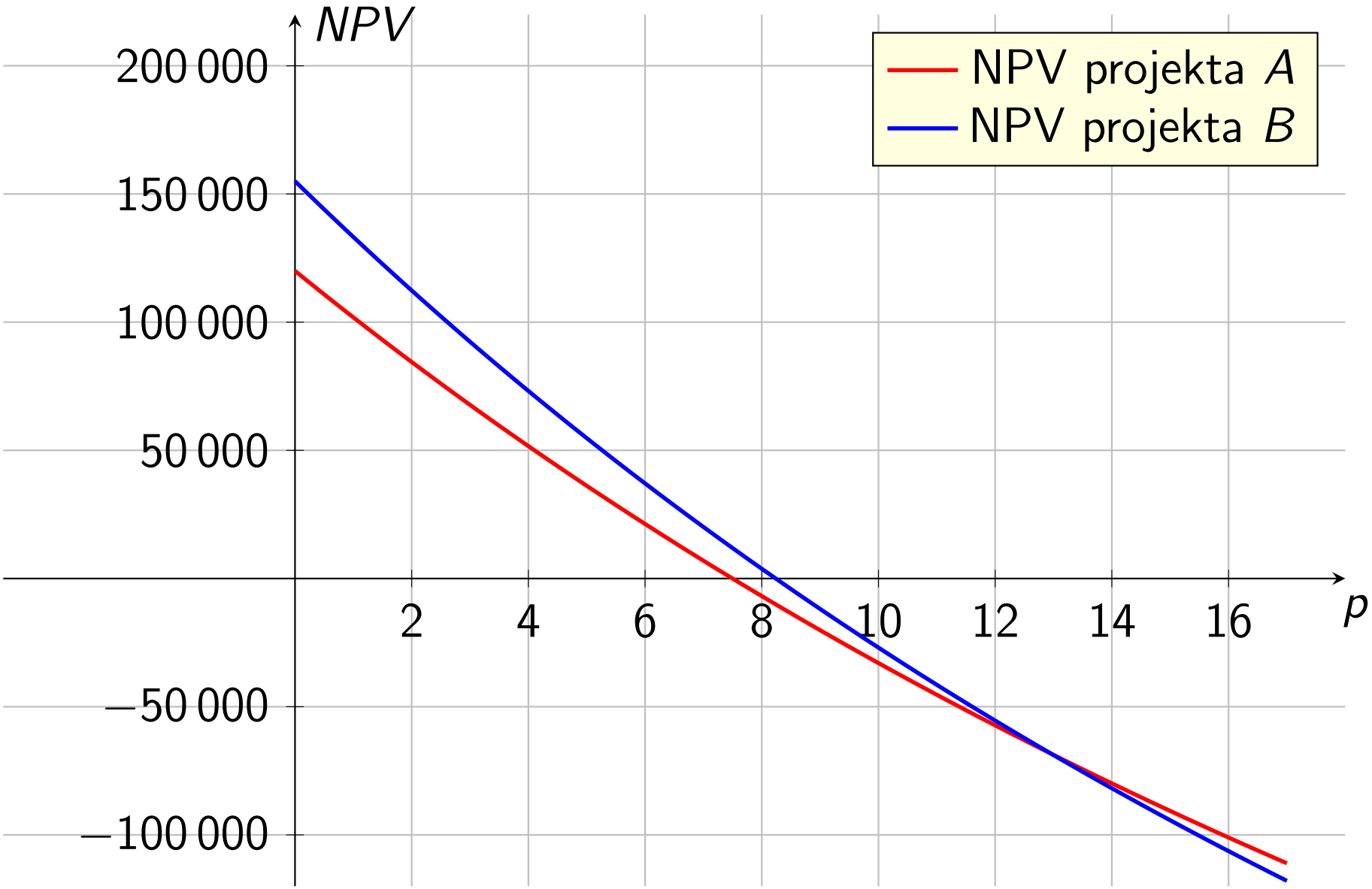
$$NPV(A) = -6851.37$$

$$NPV(B) = -600\,000 + \frac{100\,000}{1.08} + \frac{140\,000}{1.08^2} + \frac{215\,000}{1.08^3} + \frac{300\,000}{1.08^4}$$

$$NPV(B) = 3802.92$$

Isplativiji je projekt $B$. Projekt $A$ nije isplativ jer je $NPV(A) < 0$.

# NPV projekata $A$ i $B$ kao funkcija cijene kapitala



# drugi zadatak

## Zadatak 2

*Investitoru je ponuđen projekt u koji bi trebalo uložiti* 1800 *kn odmah i* 10 500 *kn za dvije godine. Očekivani dobici na kraju prve tri godine su dani u tablici.*

| *godina* | *1.* | *2.* | *3.* |
|---|---|---|---|
| *očekivani dobici* | 6050 *kn* | 3750 *kn* | 2500 *kn* |

a) *Radi li se o isplativom projektu ako je cijena kapitala* 8%*?*

b) *Radi li se o isplativom projektu ako je cijena kapitala* 12%*?*

## Rješenje

a)

| godina | 1. | 2. | 3. |
|---|---|---|---|
| očekivani dobici | 6050 kn | 3750 kn | 2500 kn |

Izračunamo $NPV$ danog projekta ako je cijena kapitala 8%.

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

## Rješenje

a)

| godina | 1. | 2. | 3. |
|---|---|---|---|
| očekivani dobici | 6050 kn | 3750 kn | 2500 kn |

Izračunamo $NPV$ danog projekta ako je cijena kapitala 8%.

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

$$NPV = -1800 + \frac{6050}{1.08} + \frac{3750 - 10\,500}{1.08^2} + \frac{2500}{1.08^3}$$

## Rješenje

a)

| godina | 1. | 2. | 3. |
|---|---|---|---|
| očekivani dobici | 6050 kn | 3750 kn | 2500 kn |

Izračunamo $NPV$ danog projekta ako je cijena kapitala 8%.

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

$$NPV = -1800 + \frac{6050}{1.08} + \frac{3750 - 10\,500}{1.08^2} + \frac{2500}{1.08^3}$$

$$NPV = -0.6046$$

## Rješenje

a)

| godina | 1. | 2. | 3. |
|---|---|---|---|
| očekivani dobici | 6050 kn | 3750 kn | 2500 kn |

Izračunamo $NPV$ danog projekta ako je cijena kapitala 8%.

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

$$NPV = -1800 + \frac{6050}{1.08} + \frac{3750 - 10\,500}{1.08^2} + \frac{2500}{1.08^3}$$

$$NPV = -0.6046$$

Kako je $NPV < 0$, projekt nije isplativ uz cijenu kapitala od 8%.

b)

| godina | 1. | 2. | 3. |
|---|---|---|---|
| očekivani dobici | 6050 kn | 3750 kn | 2500 kn |

Izračunamo $NPV$ danog projekta ako je cijena kapitala 12%.

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

b)

| godina | 1. | 2. | 3. |
|---|---|---|---|
| očekivani dobici | 6050 kn | 3750 kn | 2500 kn |

Izračunamo *NPV* danog projekta ako je cijena kapitala 12%.

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

$$NPV = -1800 + \frac{6050}{1.12} + \frac{3750 - 10\,500}{1.12^2} + \frac{2500}{1.12^3}$$

b)

| godina | 1. | 2. | 3. |
|---|---|---|---|
| očekivani dobici | 6050 kn | 3750 kn | 2500 kn |

Izračunamo *NPV* danog projekta ako je cijena kapitala 12%.

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

$$NPV = -1800 + \frac{6050}{1.12} + \frac{3750 - 10\,500}{1.12^2} + \frac{2500}{1.12^3}$$

$$NPV = 0.18$$

b)

| godina | 1. | 2. | 3. |
|---|---|---|---|
| očekivani dobici | 6050 kn | 3750 kn | 2500 kn |

Izračunamo $NPV$ danog projekta ako je cijena kapitala 12%.

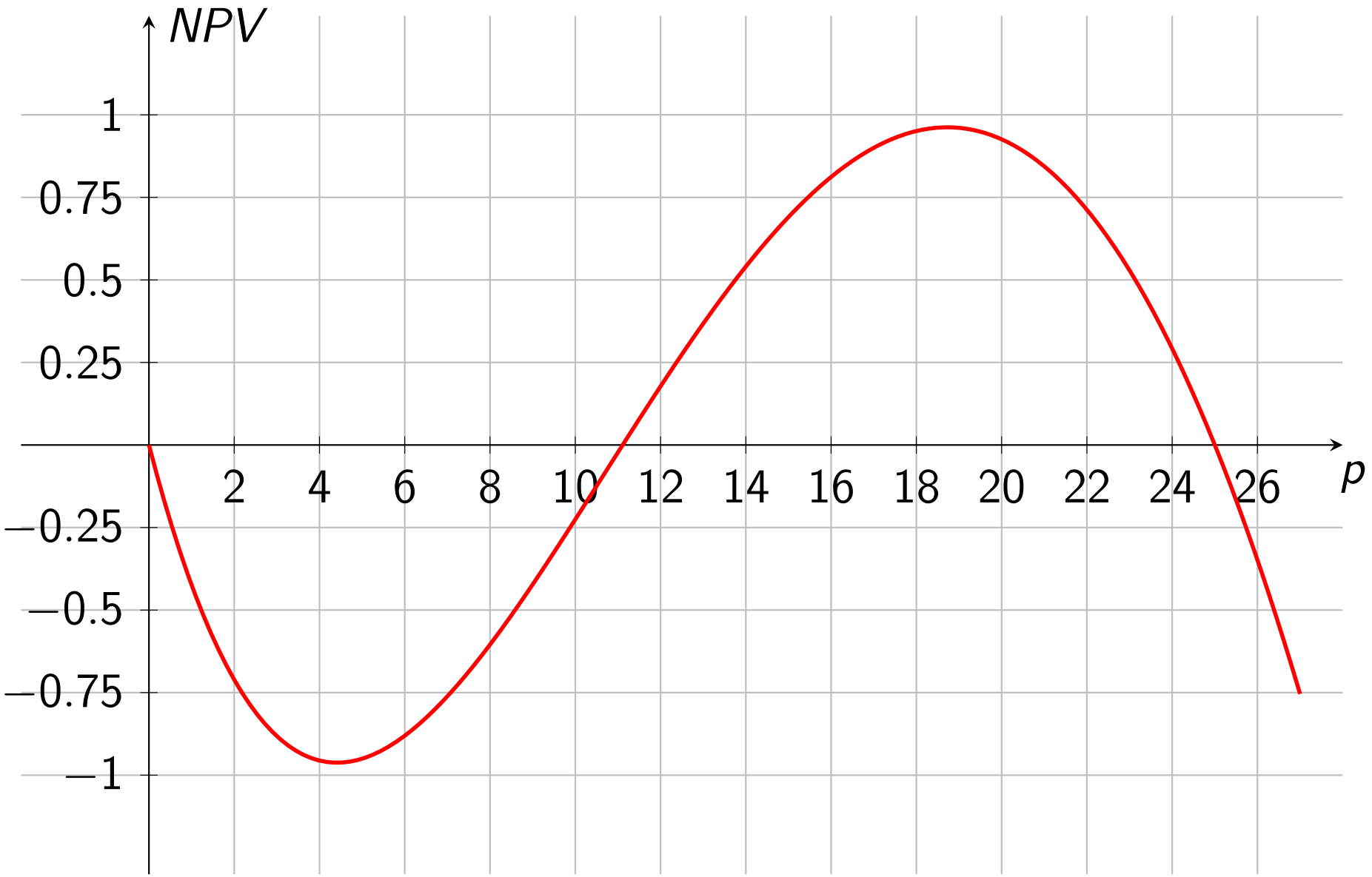
$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

$$NPV = -1800 + \frac{6050}{1.12} + \frac{3750 - 10\,500}{1.12^2} + \frac{2500}{1.12^3}$$

$$NPV = 0.18$$

Kako je $NPV > 0$, projekt je isplativ uz cijenu kapitala od 12%.

# NPV projekta kao funkcija cijene kapitala



# treći zadatak

## Zadatak 3

*U projekt treba uložiti* 9 000 €. *Očekivani dobici na kraju prve tri godine su dani u tablici.*

| *godina* | *1.* | *2.* | *3.* |
|---|---|---|---|
| *očekivani dobici* | 3000 € | 3500 € | 4000 € |

a) *Ispitajte koja je od ponuđenih kamatnih stopa* 4.5445% *i* 7.7285% *bolja aproksimacija za IRR zadanog projekta.*

b) *Uz koju cijenu kapitala je promatrani projekt isplativ?*

c) *Ako je cijena kapitala* 5%, *do kojeg uloženog iznosa je investitoru projekt isplativ?*

## Rješenje

a)

| godina | 1. | 2. | 3. |
|---|---|---|---|
| očekivani dobici | 3000 € | 3500 € | 4000 € |

Izračunamo $NPV$ danog projekta za cijenu kapitala 4.5445%.

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

## Rješenje

a)

| godina | 1. | 2. | 3. |
|---|---|---|---|
| očekivani dobici | 3000 € | 3500 € | 4000 € |

Izračunamo $NPV$ danog projekta za cijenu kapitala 4.5445%.

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

$$NPV = -9000 + \frac{3000}{1.045445} + \frac{3500}{1.045445^2} + \frac{4000}{1.045445^3}$$

## Rješenje

a)

| godina | 1. | 2. | 3. |
|---|---|---|---|
| očekivani dobici | 3000 € | 3500 € | 4000 € |

Izračunamo $NPV$ danog projekta za cijenu kapitala 4.5445%.

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

$$NPV = -9000 + \frac{3000}{1.045445} + \frac{3500}{1.045445^2} + \frac{4000}{1.045445^3}$$

$$NPV = 572.63064$$

| godina | 1. | 2. | 3. |
|---|---|---|---|
| očekivani dobici | 3000 € | 3500 € | 4000 € |

Izračunamo $NPV$ danog projekta za cijenu kapitala 7.7285%.

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

| godina | 1. | 2. | 3. |
|---|---|---|---|
| očekivani dobici | 3000 € | 3500 € | 4000 € |

Izračunamo $NPV$ danog projekta za cijenu kapitala 7.7285%.

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

$$NPV = -9000 + \frac{3000}{1.077285} + \frac{3500}{1.077285^2} + \frac{4000}{1.077285^3}$$

| godina | 1. | 2. | 3. |
|---|---|---|---|
| očekivani dobici | 3000 € | 3500 € | 4000 € |

Izračunamo $NPV$ danog projekta za cijenu kapitala 7.7285%.

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

$$NPV = -9000 + \frac{3000}{1.077285} + \frac{3500}{1.077285^2} + \frac{4000}{1.077285^3}$$

$$NPV = 0.00528$$

| godina | 1. | 2. | 3. |
|---|---|---|---|
| očekivani dobici | 3000 € | 3500 € | 4000 € |

Izračunamo $NPV$ danog projekta za cijenu kapitala 7.7285%.

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

$$NPV = -9000 + \frac{3000}{1.077285} + \frac{3500}{1.077285^2} + \frac{4000}{1.077285^3}$$

$$NPV = 0.00528$$

Kako je za cijenu kapitala 7.7285% $NPV$ projekta bliže nuli, zaključujemo da je kamatna stopa 7.7285% bolja aproksimacija za $IRR$ danog projekta.

b) Projekt je isplativ po onoj cijeni kapitala $p$ za koju vrijedi

$$p < IRR.$$

Iz prethodnog dijela zadatka smo dobili da je 7.7285% jako dobra aproksimacija za $IRR$ promatranog projekta jer je po toj kamatnoj stopi $NPV$ bio jako blizu nule. Stoga možemo reći da je projekt isplativ ako je cijena kapitala manja od 7.7285%.

c)

| godina | 1. | 2. | 3. |
|---|---|---|---|
| očekivani dobici | 3000 € | 3500 € | 4000 € |

Investitoru je projekt isplativ do onog iznosa za koji je $NPV = 0$ uz cijenu kapitala 5%.

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

c)

| godina | 1. | 2. | 3. |
|---|---|---|---|
| očekivani dobici | 3000 € | 3500 € | 4000 € |

Investitoru je projekt isplativ do onog iznosa za koji je $NPV = 0$ uz cijenu kapitala 5%.

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

$$0 = F_0 + \frac{3000}{1.05} + \frac{3500}{1.05^2} + \frac{4000}{1.05^3}$$

c)

| godina | 1. | 2. | 3. |
|---|---|---|---|
| očekivani dobici | 3000 € | 3500 € | 4000 € |

Investitoru je projekt isplativ do onog iznosa za koji je $NPV = 0$ uz cijenu kapitala 5%.

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

$$0 = F_0 + \frac{3000}{1.05} + \frac{3500}{1.05^2} + \frac{4000}{1.05^3}$$

$$F_0 = -9487.10$$

c)

| godina | 1. | 2. | 3. |
|---|---|---|---|
| očekivani dobici | 3000 € | 3500 € | 4000 € |

Investitoru je projekt isplativ do onog iznosa za koji je $NPV = 0$ uz cijenu kapitala 5%.

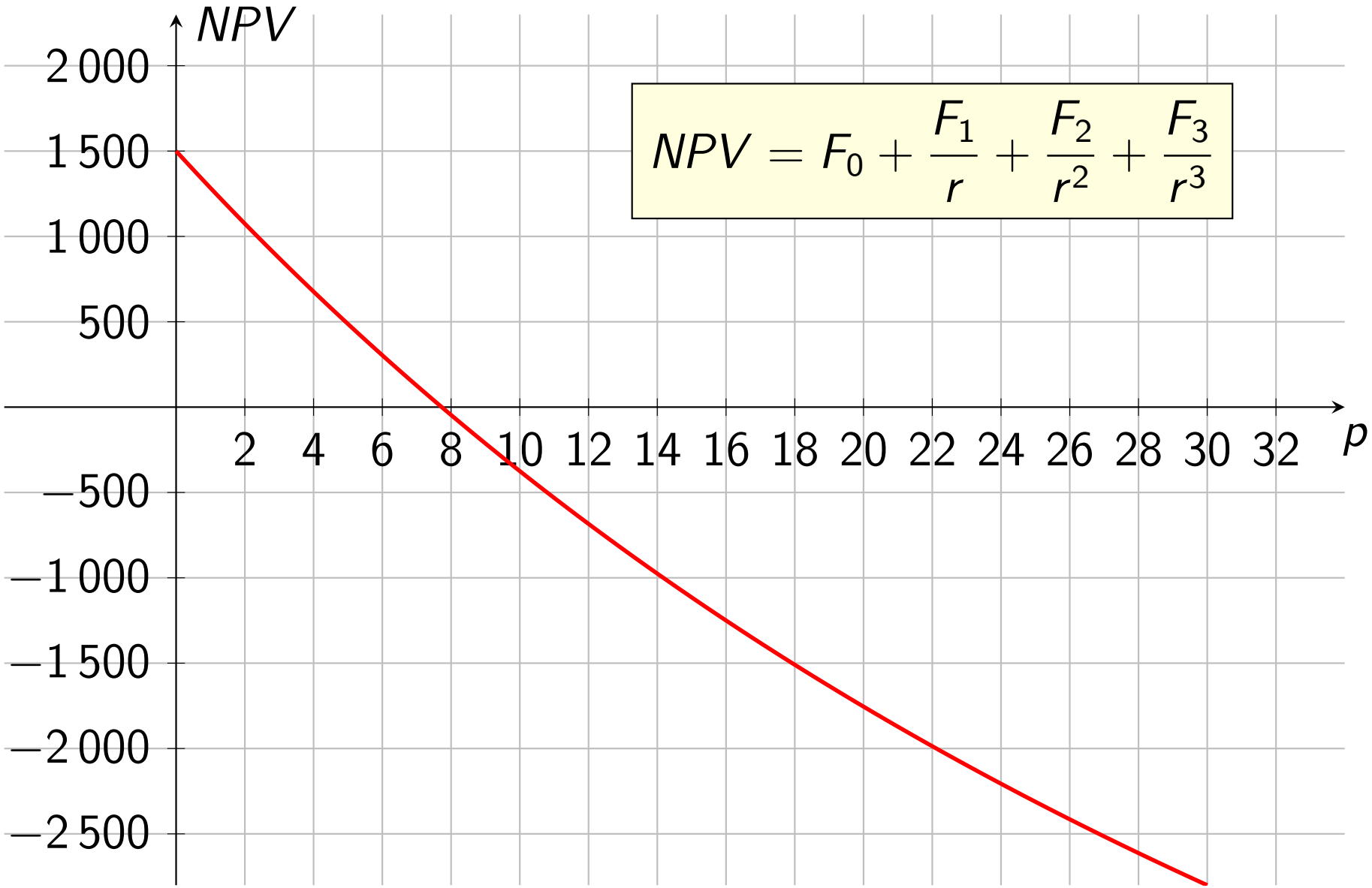
$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

$$0 = F_0 + \frac{3000}{1.05} + \frac{3500}{1.05^2} + \frac{4000}{1.05^3}$$

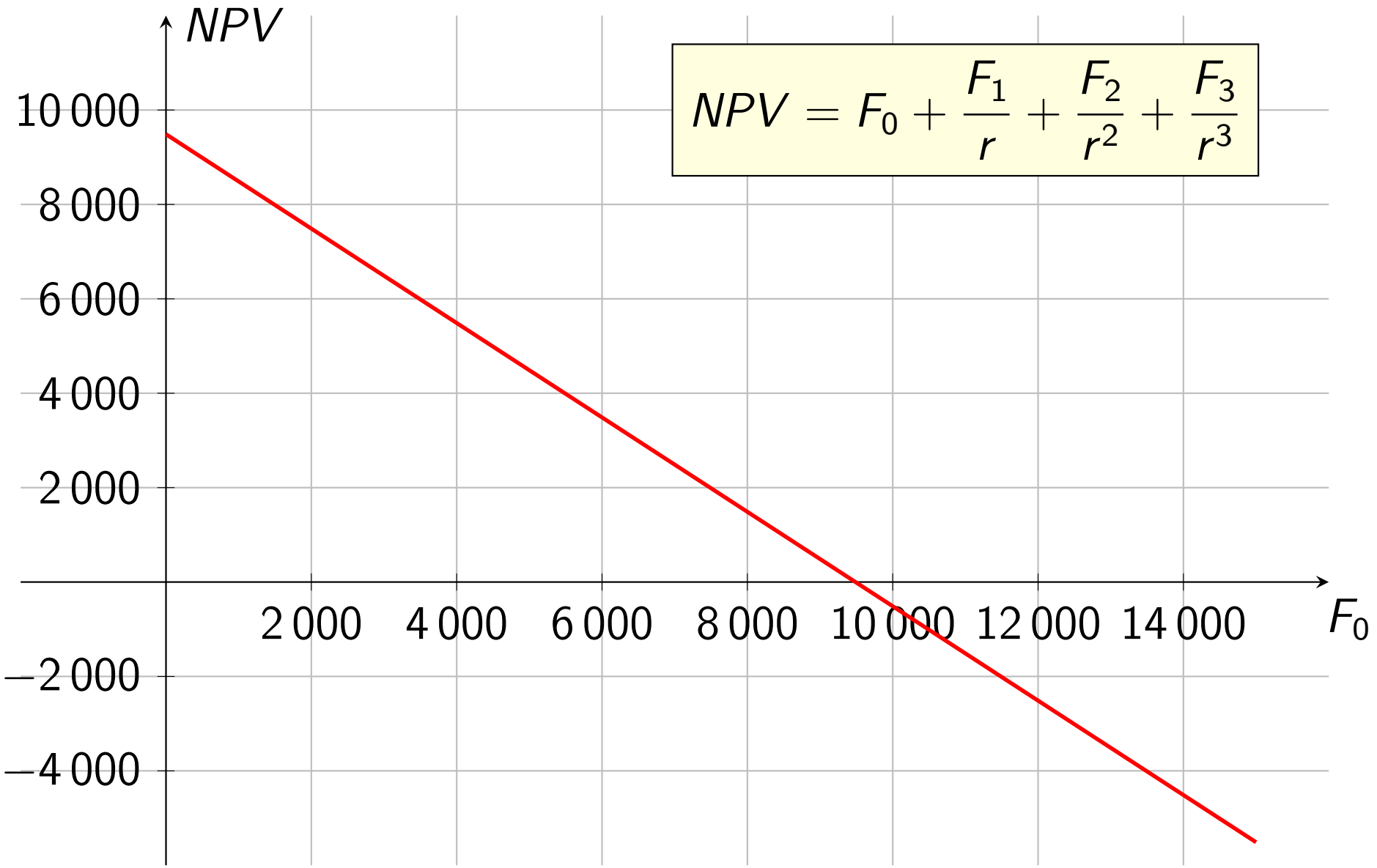
$$F_0 = -9487.10$$

Investitoru se isplati uložiti u projekt maksimalno 9487.10 €.

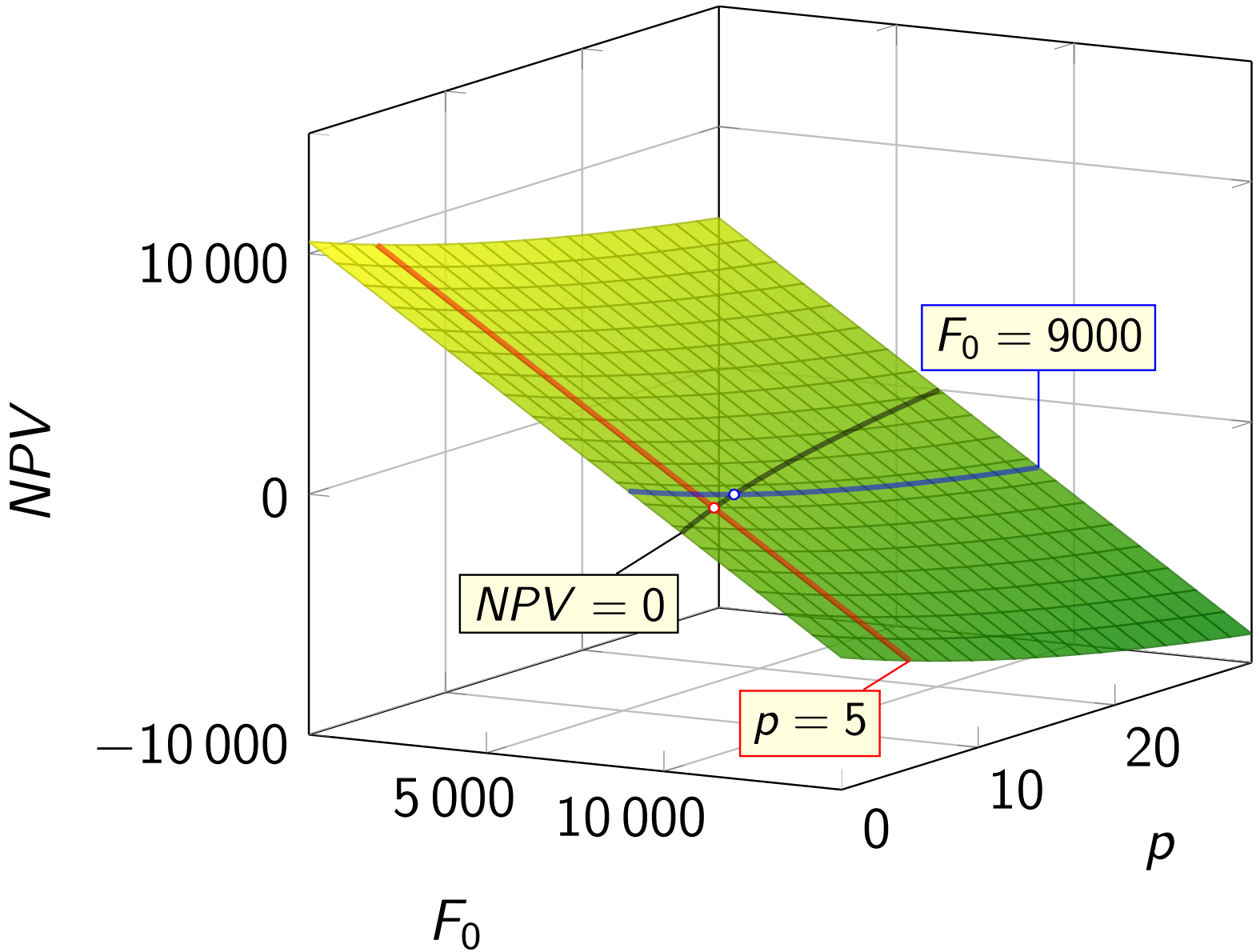
# NPV projekta kao funkcija cijene kapitala



# NPV projekta kao funkcija ulaganja uz $p = 5\%$



# NPV kao funkcija ulaganja i cijene kapitala



# četvrti zadatak

## Zadatak 4

*Koliki prihod je na kraju druge godine ostvarila investicija visine* 200 000 *kn uz cijenu kapitala* 7% *ako je NPV jednak* 14 559.82 *kn, a prihodi na kraju prve i treće godine su redom* 50 000 *kn i* 120 000 *kn?*

## Rješenje

- $r = 1.07, \quad NPV = 14\,559.82,$
  $F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_3 = 120\,000$

## Rješenje

- $r = 1.07, \quad NPV = 14\,559.82,$
  $F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_3 = 120\,000$

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

## Rješenje

- $r = 1.07, \quad NPV = 14\,559.82,$
  $F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_3 = 120\,000$

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

$$\frac{F_2}{r^2} = NPV - F_0 - \frac{F_1}{r} - \frac{F_3}{r^3}$$

## Rješenje

- $r = 1.07, \quad NPV = 14\,559.82,$
  $F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_3 = 120\,000$

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

$$\frac{F_2}{r^2} = NPV - F_0 - \frac{F_1}{r} - \frac{F_3}{r^3}$$

$$F_2 = r^2 \cdot \left( NPV - F_0 - \frac{F_1}{r} - \frac{F_3}{r^3} \right)$$

## Rješenje

- $r = 1.07, \quad NPV = 14\,559.82,$
  $F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_3 = 120\,000$

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

$$\frac{F_2}{r^2} = NPV - F_0 - \frac{F_1}{r} - \frac{F_3}{r^3}$$

$$F_2 = r^2 \cdot \left( NPV - F_0 - \frac{F_1}{r} - \frac{F_3}{r^3} \right)$$

$$F_2 = 1.07^2 \cdot \left( 14\,559.82 + 200\,000 - \frac{50\,000}{1.07} - \frac{120\,000}{1.07^3} \right)$$

## Rješenje

- $r = 1.07, \quad NPV = 14\,559.82,$
  $F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_3 = 120\,000$

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

$$\frac{F_2}{r^2} = NPV - F_0 - \frac{F_1}{r} - \frac{F_3}{r^3}$$

$$F_2 = r^2 \cdot \left( NPV - F_0 - \frac{F_1}{r} - \frac{F_3}{r^3} \right)$$

$$F_2 = 1.07^2 \cdot \left( 14\,559.82 + 200\,000 - \frac{50\,000}{1.07} - \frac{120\,000}{1.07^3} \right)$$

$$F_2 = 80\,000.01$$

## Rješenje

- $r = 1.07, \quad NPV = 14\,559.82,$
  $F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_3 = 120\,000$

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3}$$

$$\frac{F_2}{r^2} = NPV - F_0 - \frac{F_1}{r} - \frac{F_3}{r^3}$$

$$F_2 = r^2 \cdot \left( NPV - F_0 - \frac{F_1}{r} - \frac{F_3}{r^3} \right)$$

$$F_2 = 1.07^2 \cdot \left( 14\,559.82 + 200\,000 - \frac{50\,000}{1.07} - \frac{120\,000}{1.07^3} \right)$$

$$F_2 = 80\,000.01$$

Na kraju druge godine ostvaren je prihod od 80 000.01 kn.

# peti zadatak

## Zadatak 5

*NPV i IRR metodom ocijenite je li isplativ projekt u koji treba uložiti* 200 000 *kn, a koji na kraju prve godine donosi* 50 000 *kn, a na kraju druge godine* 180 000 *kn dobiti. Investitor sredstva za ulaganje u projekt posuđuje po godišnjoj kamatnoj stopi od* 7%.

## Rješenje

- $r = 1.07, \quad F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_2 = 180\,000$

## Rješenje

- $r = 1.07, \quad F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_2 = 180\,000$

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2}$$

## Rješenje

- $r = 1.07, \quad F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_2 = 180\,000$

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2}$$

$$NPV = -200\,000 + \frac{50\,000}{1.07} + \frac{180\,000}{1.07^2}$$

## Rješenje

- $r = 1.07, \quad F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_2 = 180\,000$

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2}$$

$$NPV = -200\,000 + \frac{50\,000}{1.07} + \frac{180\,000}{1.07^2}$$

$$NPV = 3947.94$$

## Rješenje

- $r = 1.07, \quad F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_2 = 180\,000$

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2}$$

$$NPV = -200\,000 + \frac{50\,000}{1.07} + \frac{180\,000}{1.07^2}$$

$$NPV = 3947.94$$

Kako je $NPV > 0$, radi se o isplativom projektu.

- $r_1 = 1 + \frac{IRR}{100}, \quad F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_2 = 180\,000$

- $r_1 = 1 + \frac{IRR}{100}, \quad F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_2 = 180\,000$

$$NPV = 0$$

- $r_1 = 1 + \frac{IRR}{100}, \quad F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_2 = 180\,000$

$$NPV = 0$$

$$F_0 + \frac{F_1}{r_1} + \frac{F_2}{r_1^2} = 0$$

- $r_1 = 1 + \frac{IRR}{100}, \quad F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_2 = 180\,000$

$$NPV = 0$$

$$F_0 + \frac{F_1}{r_1} + \frac{F_2}{r_1^2} = 0$$

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- $r_1 = 1 + \frac{IRR}{100}, \quad F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_2 = 180\,000$

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$$F_0 + \frac{F_1}{r_1} + \frac{F_2}{r_1^2} = 0$$

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$$-20r_1^2 + 5r_1 + 18 = 0$$

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$$NPV = 0$$

$$F_0 + \frac{F_1}{r_1} + \frac{F_2}{r_1^2} = 0$$

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$$r_1 = \frac{-5 \pm \sqrt{25 - 4 \cdot (-20) \cdot 18}}{2 \cdot (-20)}$$

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$$NPV = 0$$

$$F_0 + \frac{F_1}{r_1} + \frac{F_2}{r_1^2} = 0$$

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$$r_1 = \frac{-5 \pm \sqrt{25 - 4 \cdot (-20) \cdot 18}}{2 \cdot (-20)}$$

$$r_1^{(1)} = -0.83188, \quad r_1^{(2)} = 1.08188$$

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- $r_1 = 1.08188,$

- $r_1 = 1 + \frac{IRR}{100}, \quad F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_2 = 180\,000$

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$$r_1 = \frac{-5 \pm \sqrt{25 - 4 \cdot (-20) \cdot 18}}{2 \cdot (-20)}$$

$$r_1^{(1)} = -0.83188, \quad r_1^{(2)} = 1.08188$$

- $r_1 = 1.08188, \quad IRR = 100\big(r_1 - 1\big),$

- $r_1 = 1 + \frac{IRR}{100}, \quad F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_2 = 180\,000$

$$NPV = 0$$

$$F_0 + \frac{F_1}{r_1} + \frac{F_2}{r_1^2} = 0$$

$$-200\,000 + \frac{50\,000}{r_1} + \frac{180\,000}{r_1^2} = 0 \Big/ \cdot \frac{r_1^2}{10\,000}$$

$$-20r_1^2 + 5r_1 + 18 = 0$$

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$$r_1^{(1)} = -0.83188, \quad r_1^{(2)} = 1.08188$$

- $r_1 = 1.08188, \quad IRR = 100\big(r_1 - 1\big), \quad IRR = 8.188\%$

- $r_1 = 1 + \frac{IRR}{100}, \quad F_0 = -200\,000, \quad F_1 = 50\,000, \quad F_2 = 180\,000$

$$NPV = 0$$

$$F_0 + \frac{F_1}{r_1} + \frac{F_2}{r_1^2} = 0$$

$$-200\,000 + \frac{50\,000}{r_1} + \frac{180\,000}{r_1^2} = 0 \Big/ \cdot \frac{r_1^2}{10\,000}$$

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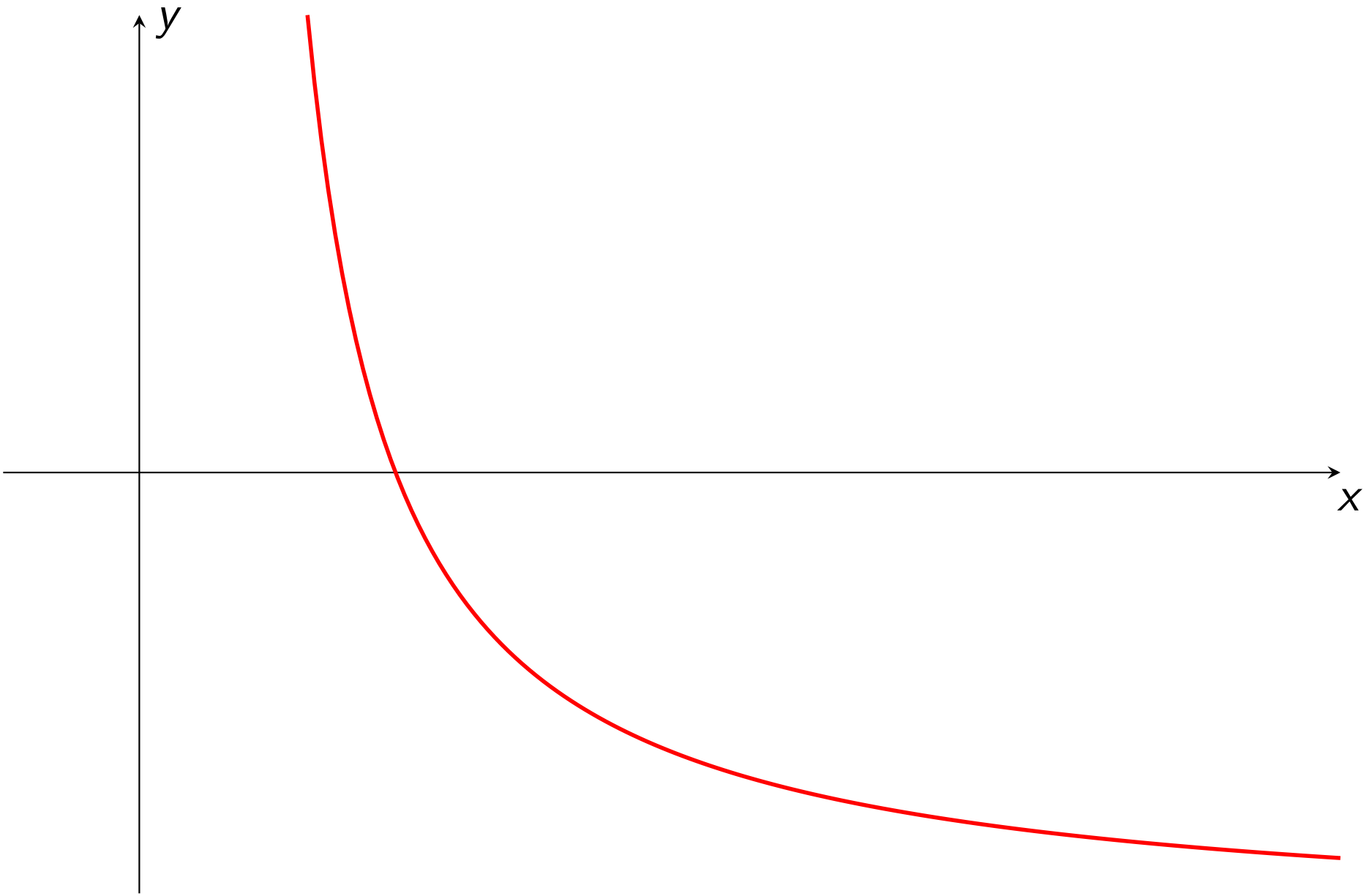
$$r_1 = \frac{-5 \pm \sqrt{25 - 4 \cdot (-20) \cdot 18}}{2 \cdot (-20)}$$

$$r_1^{(1)} = -0.83188, \quad r_1^{(2)} = 1.08188$$

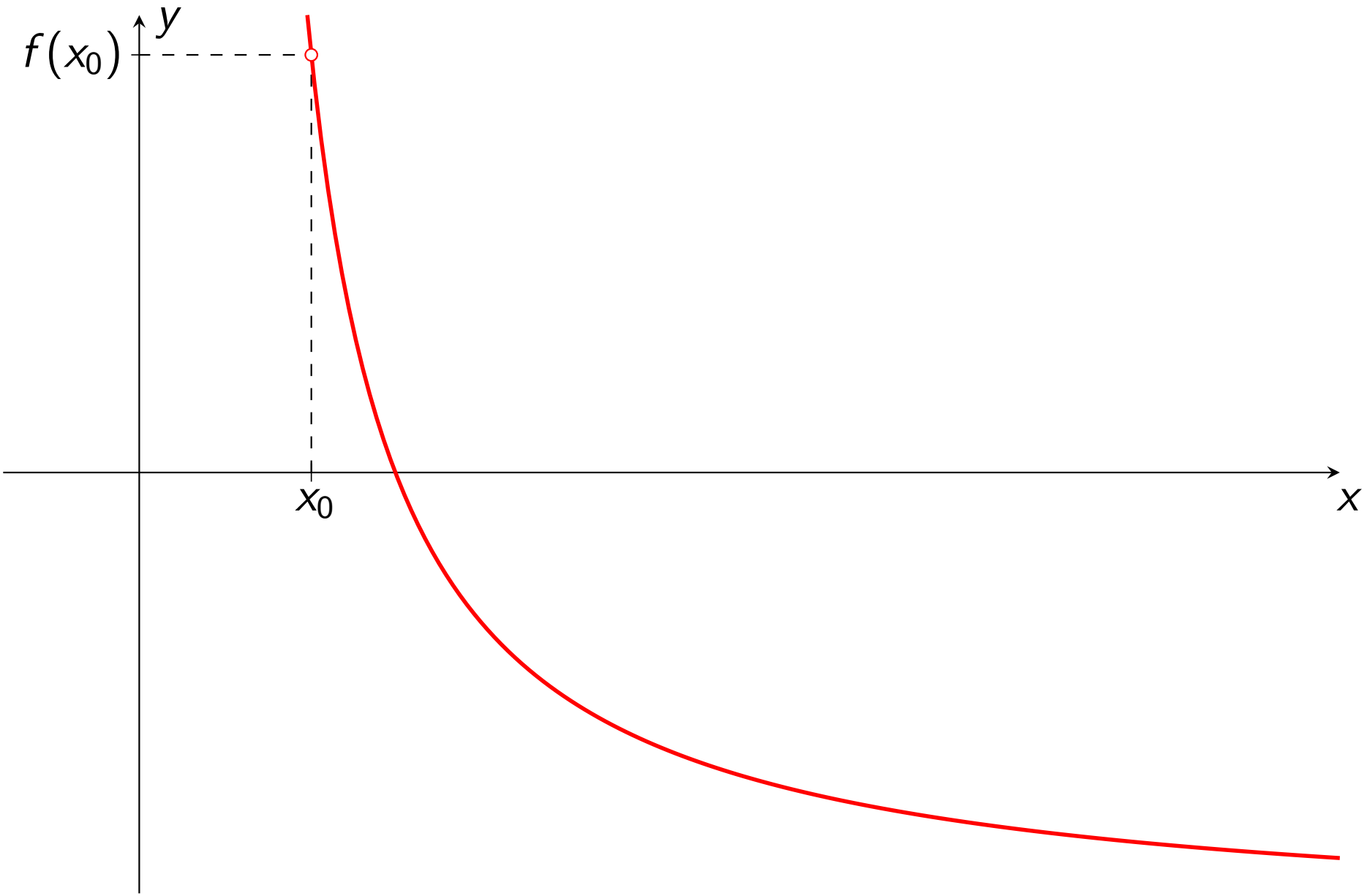
- $r_1 = 1.08188, \quad IRR = 100\big(r_1 - 1\big), \quad IRR = 8.188\%$
- *IRR* je veći od zadane cijene kapitala pa je projekt isplativ.

# Metoda Regula falsi

# Metoda Regula falsi



# Metoda Regula falsi



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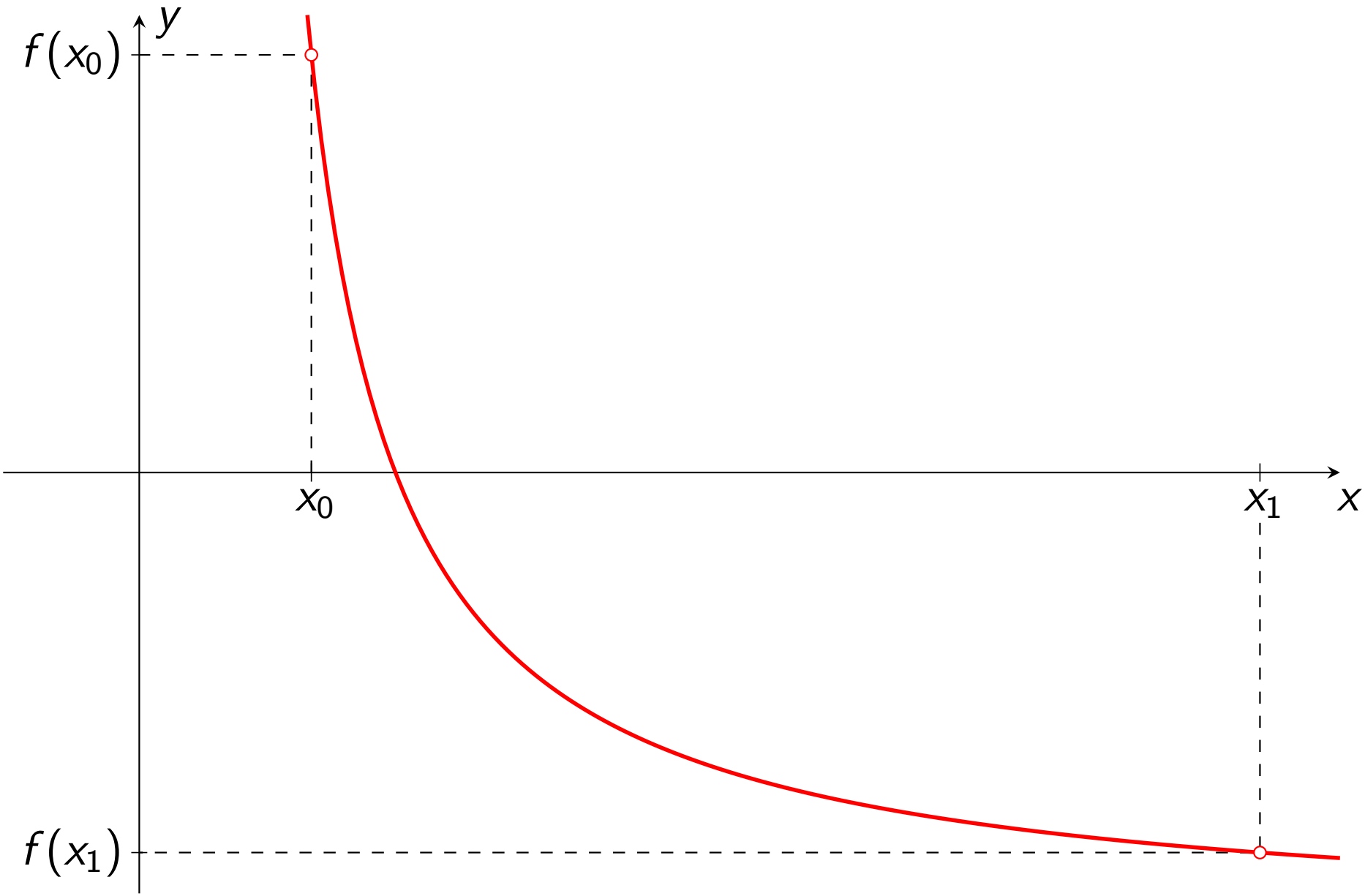
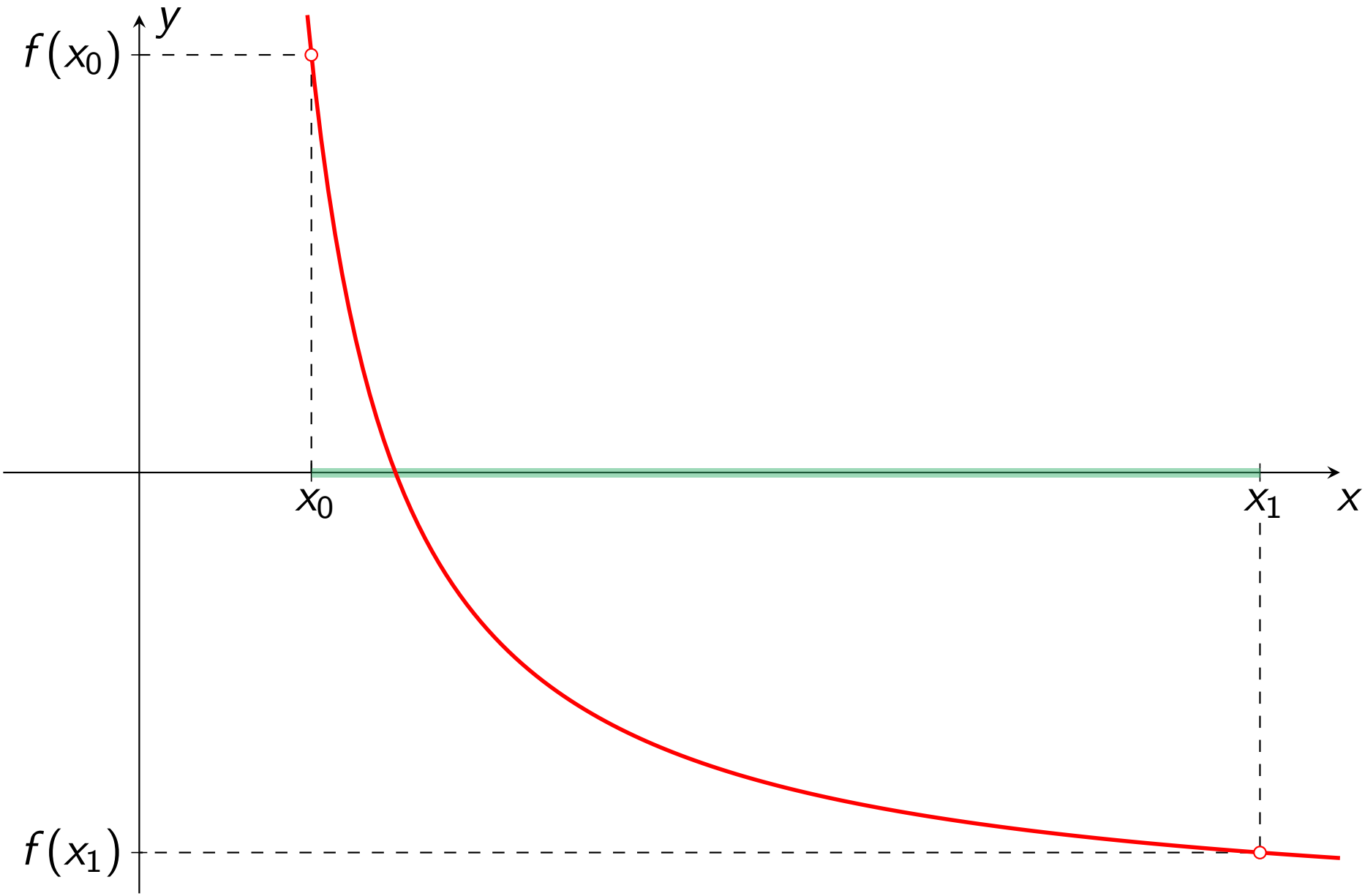


# Metoda Regula falsi



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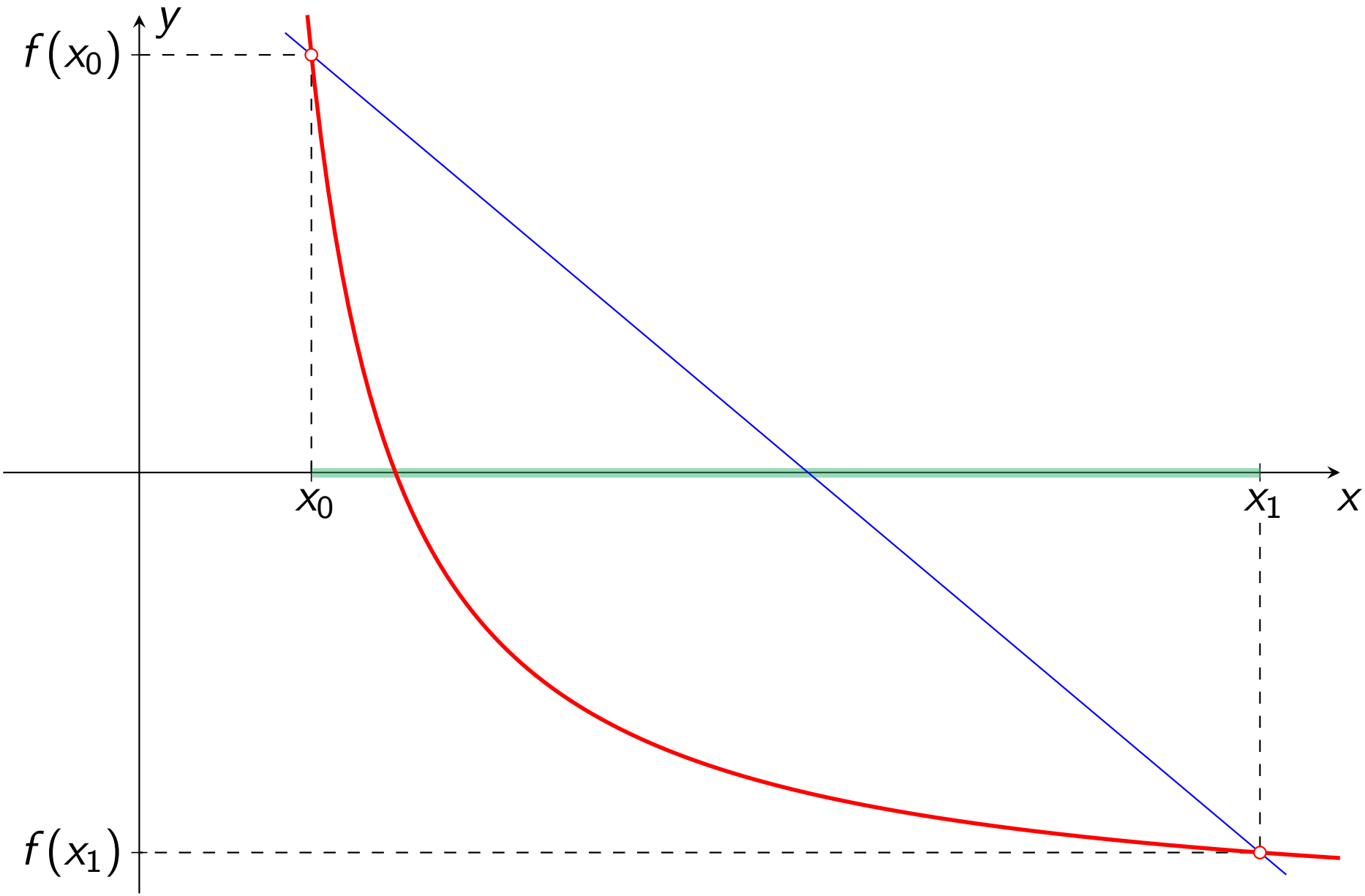
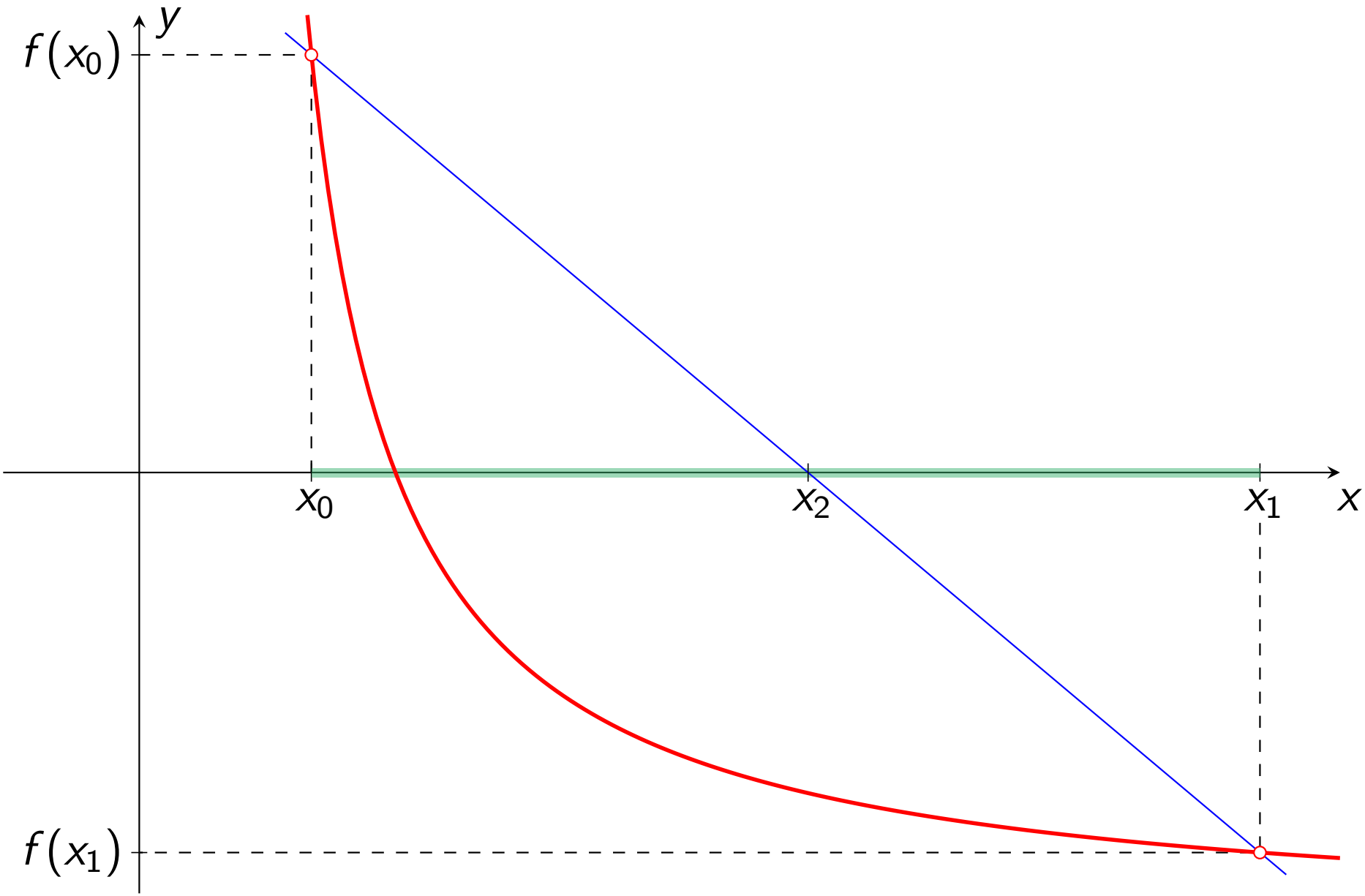
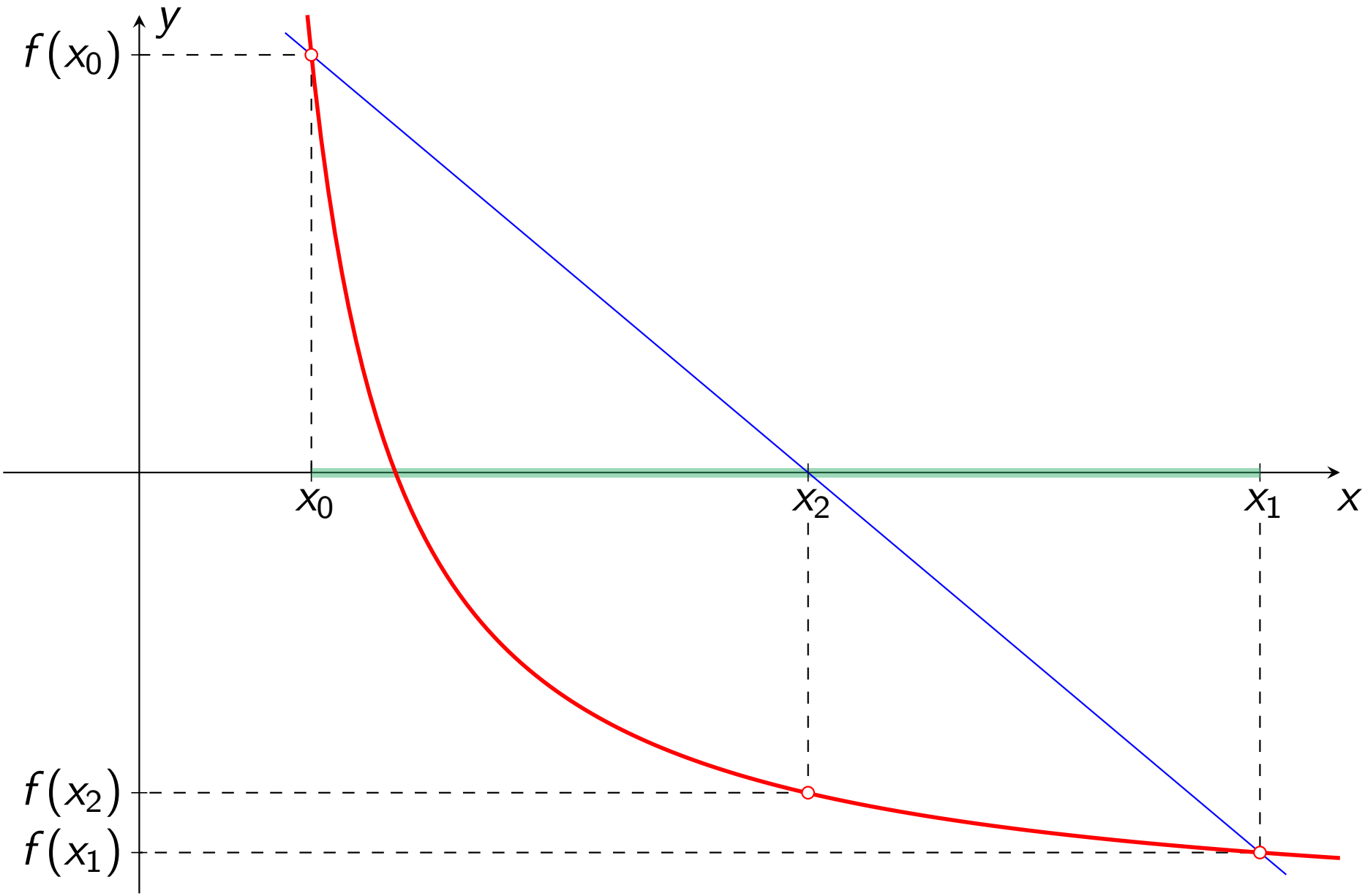


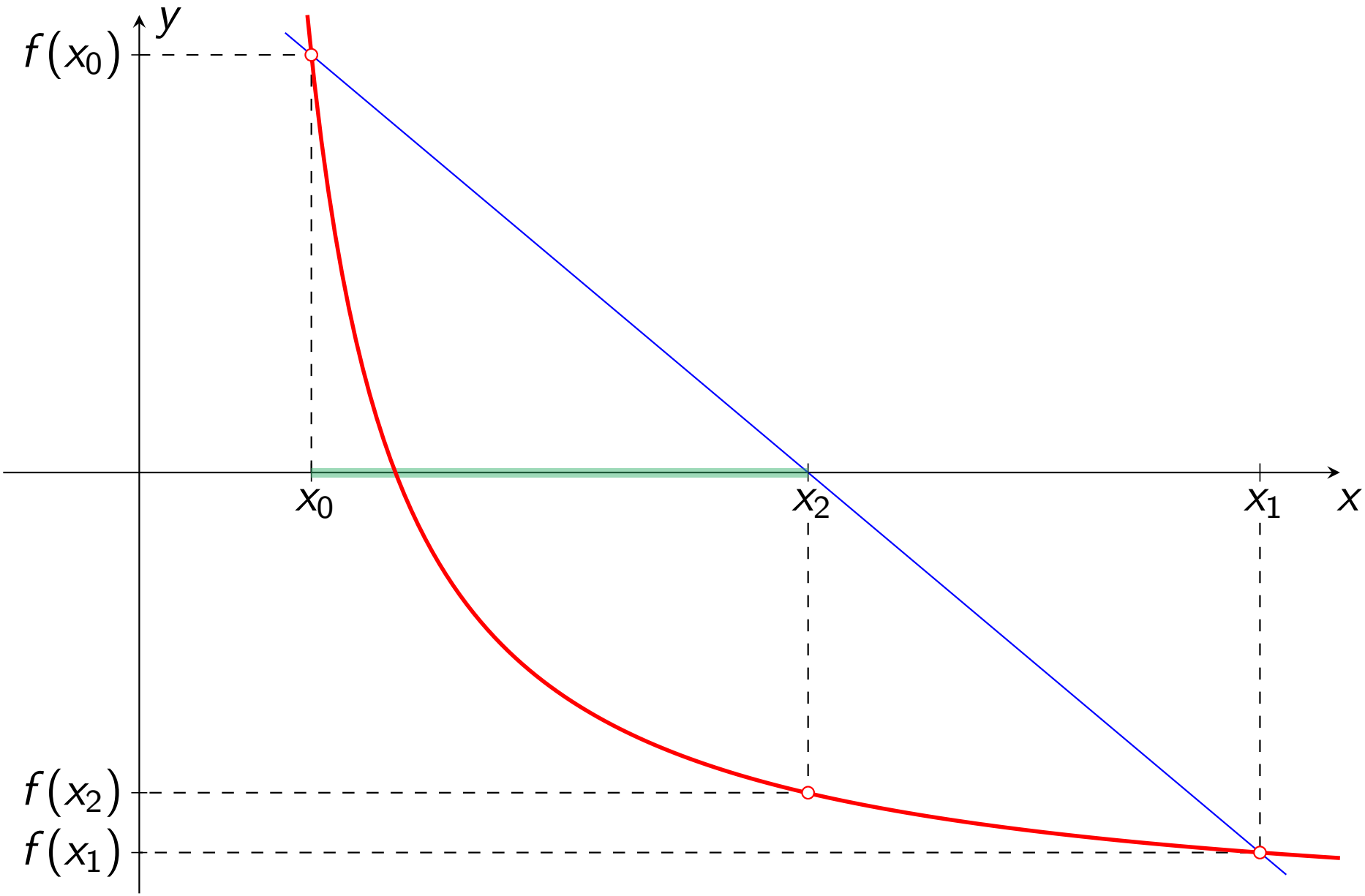
# Metoda Regula falsi



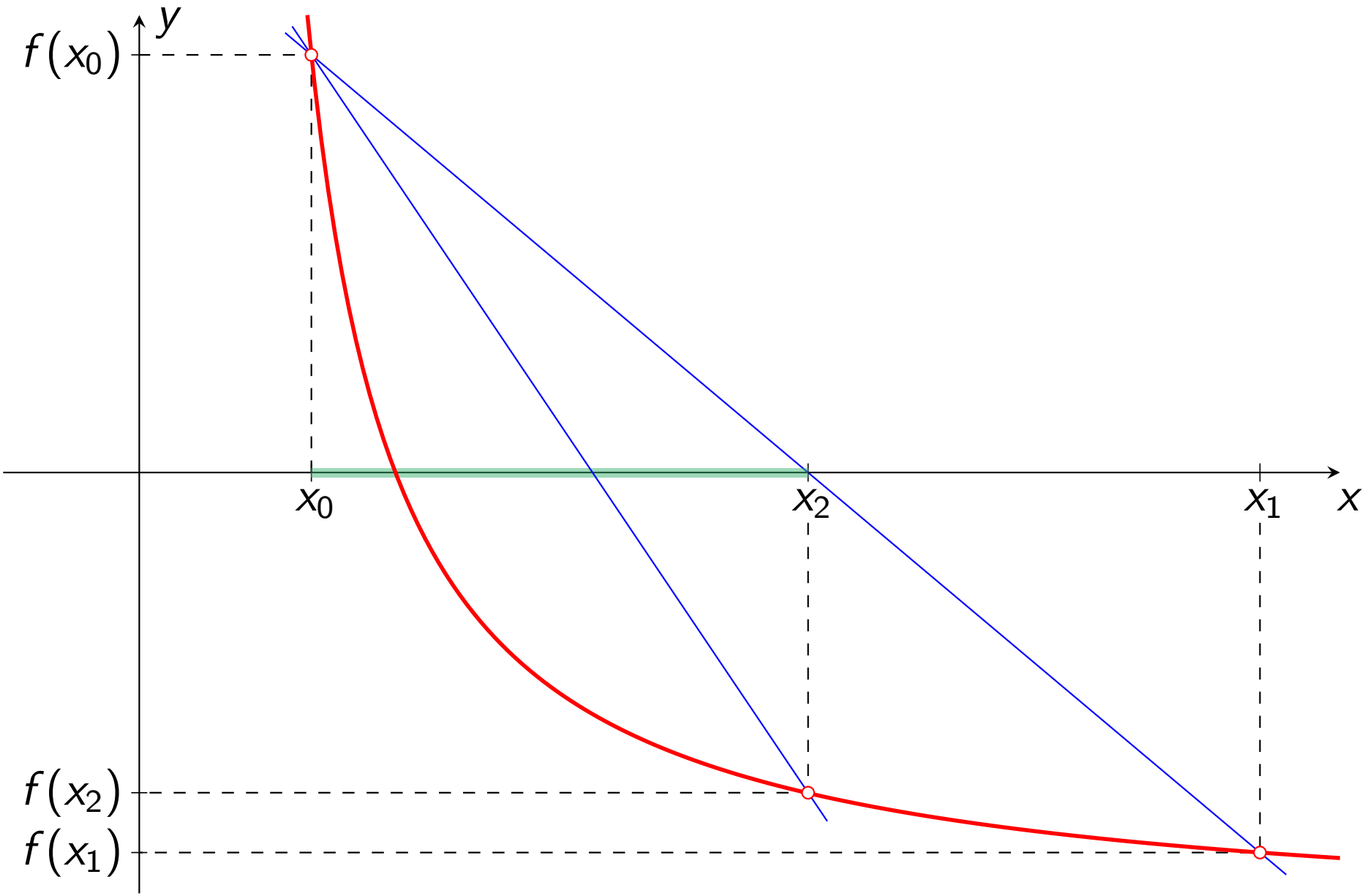
# Metoda Regula falsi



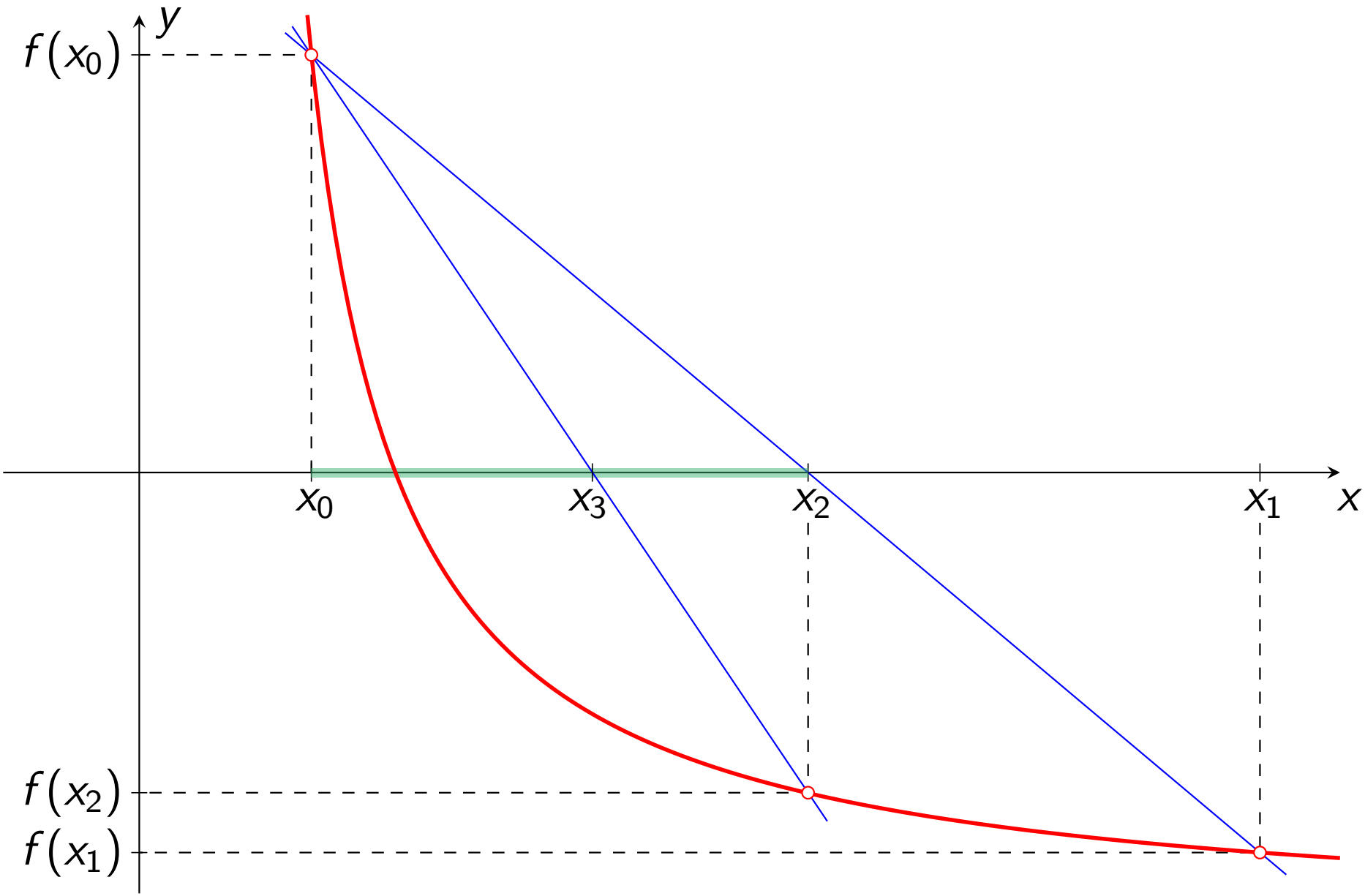
# Metoda Regula falsi



# Metoda Regula falsi



# Metoda Regula falsi



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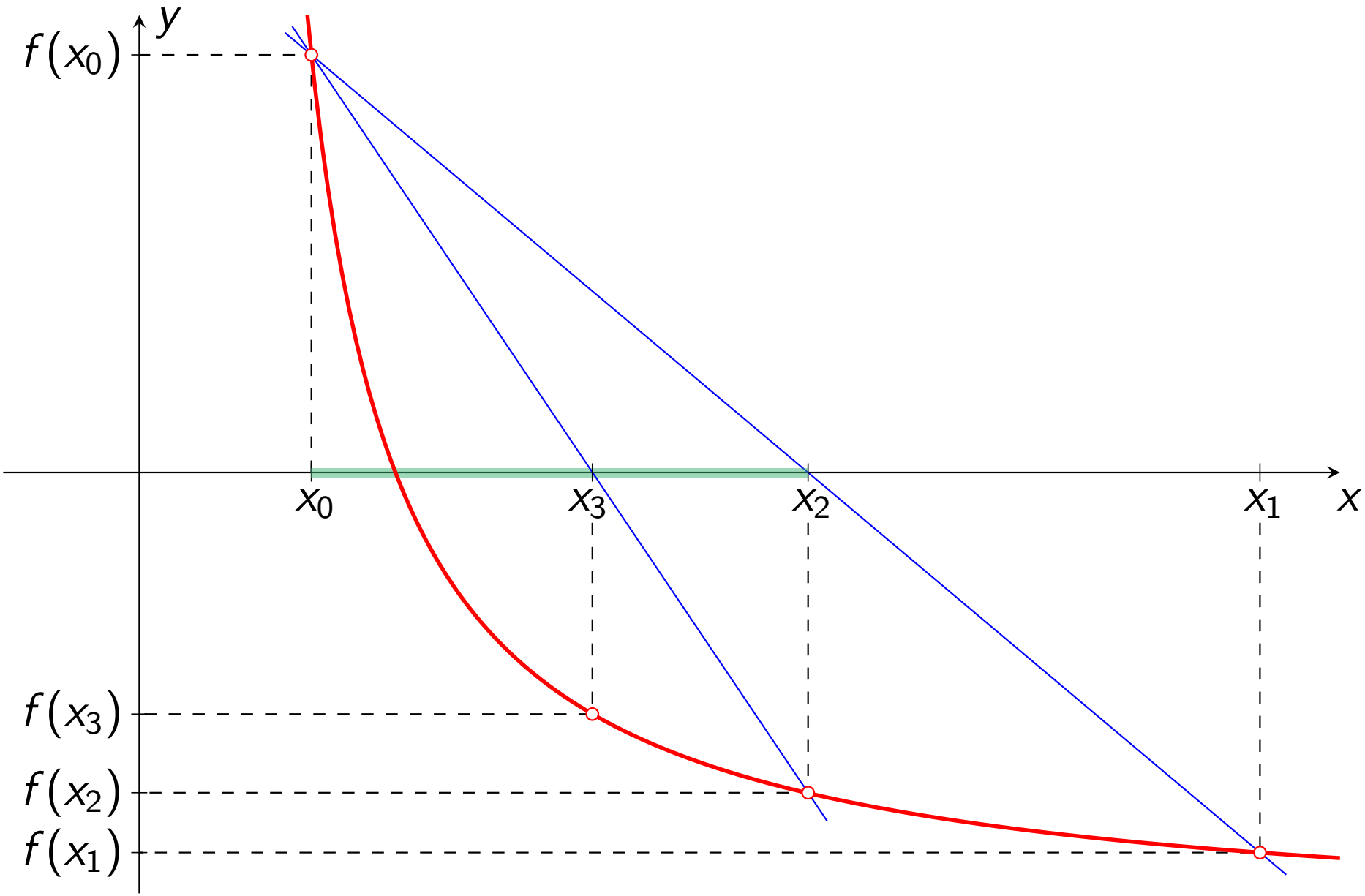

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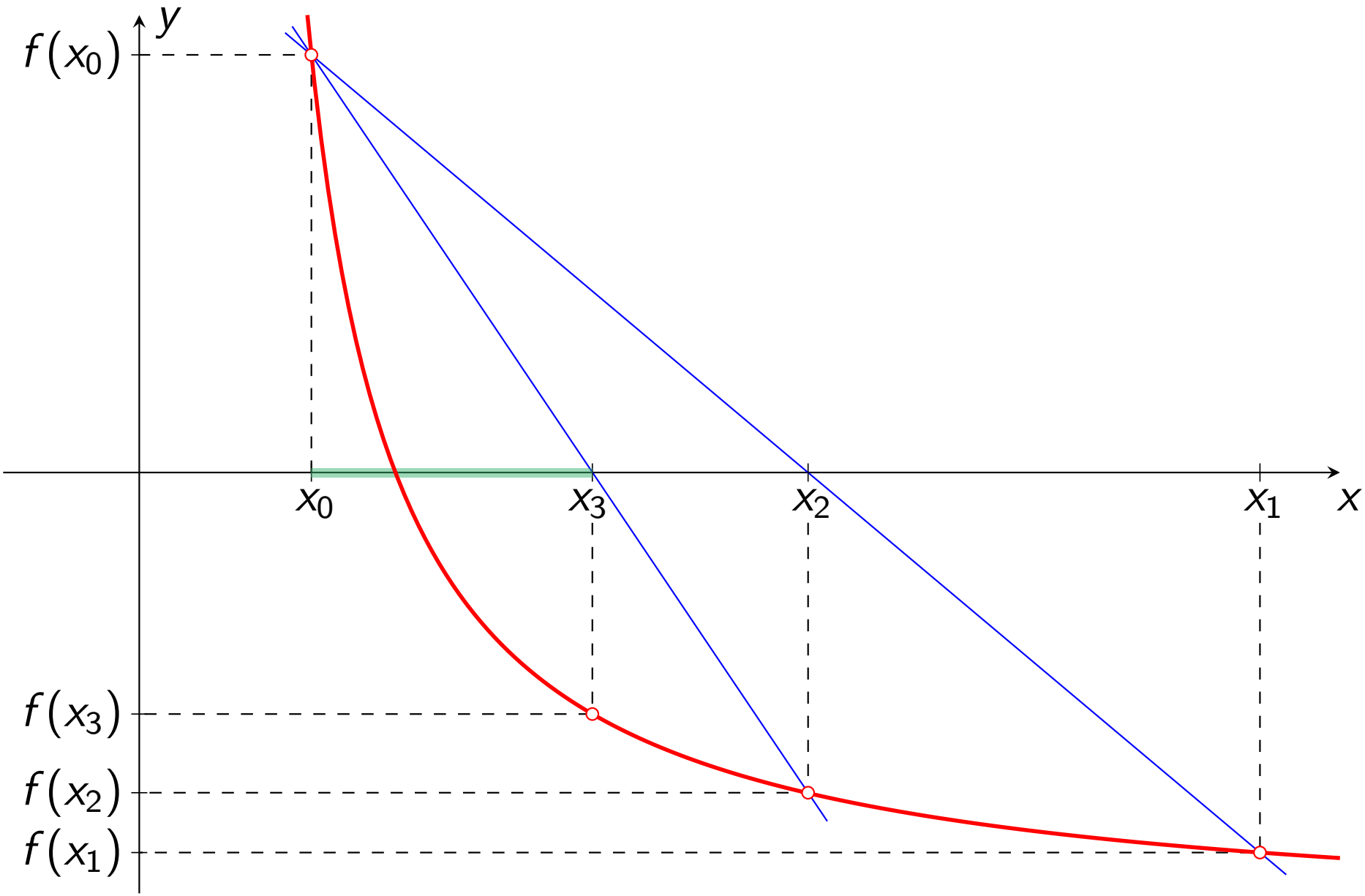

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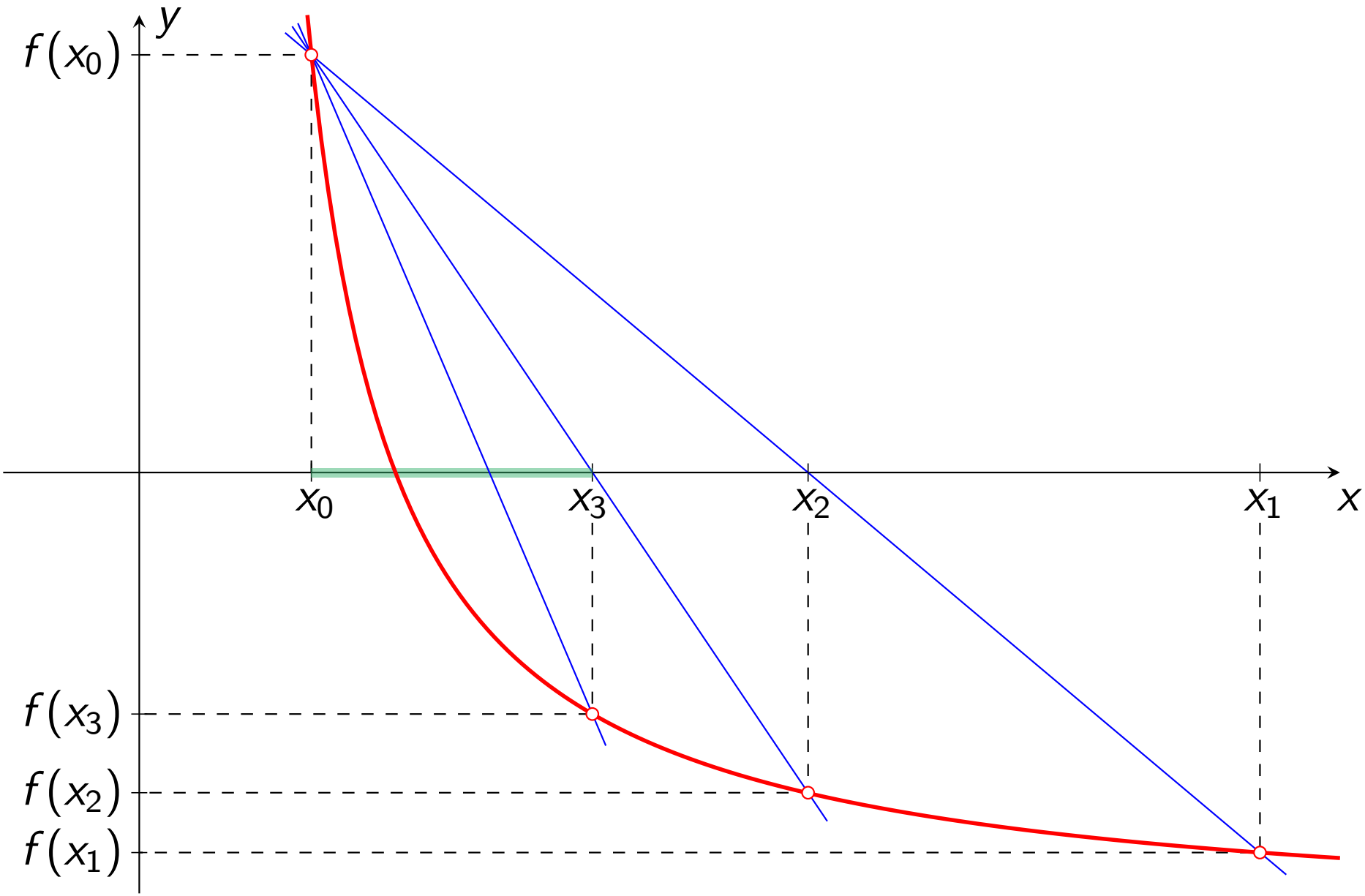

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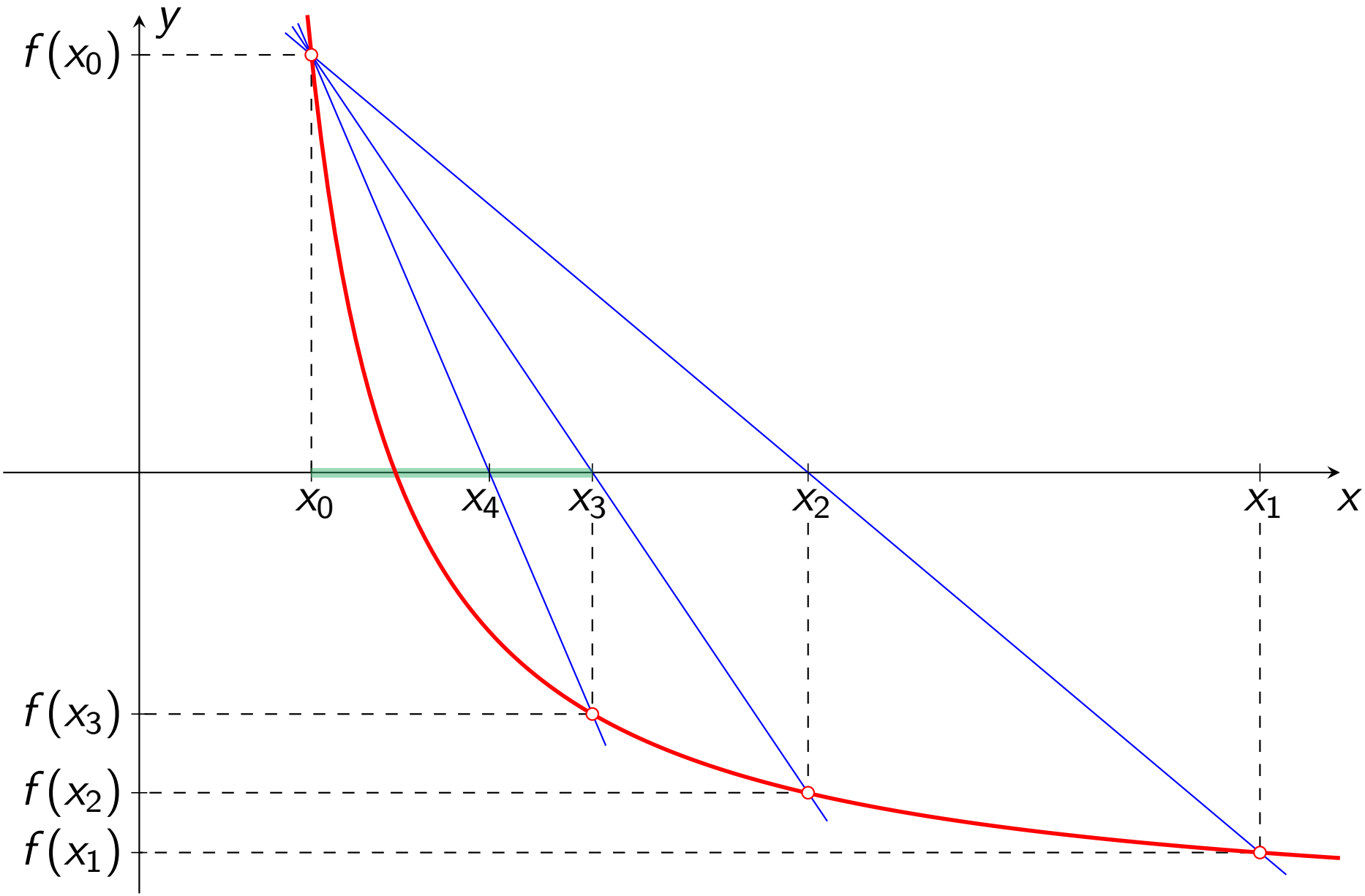

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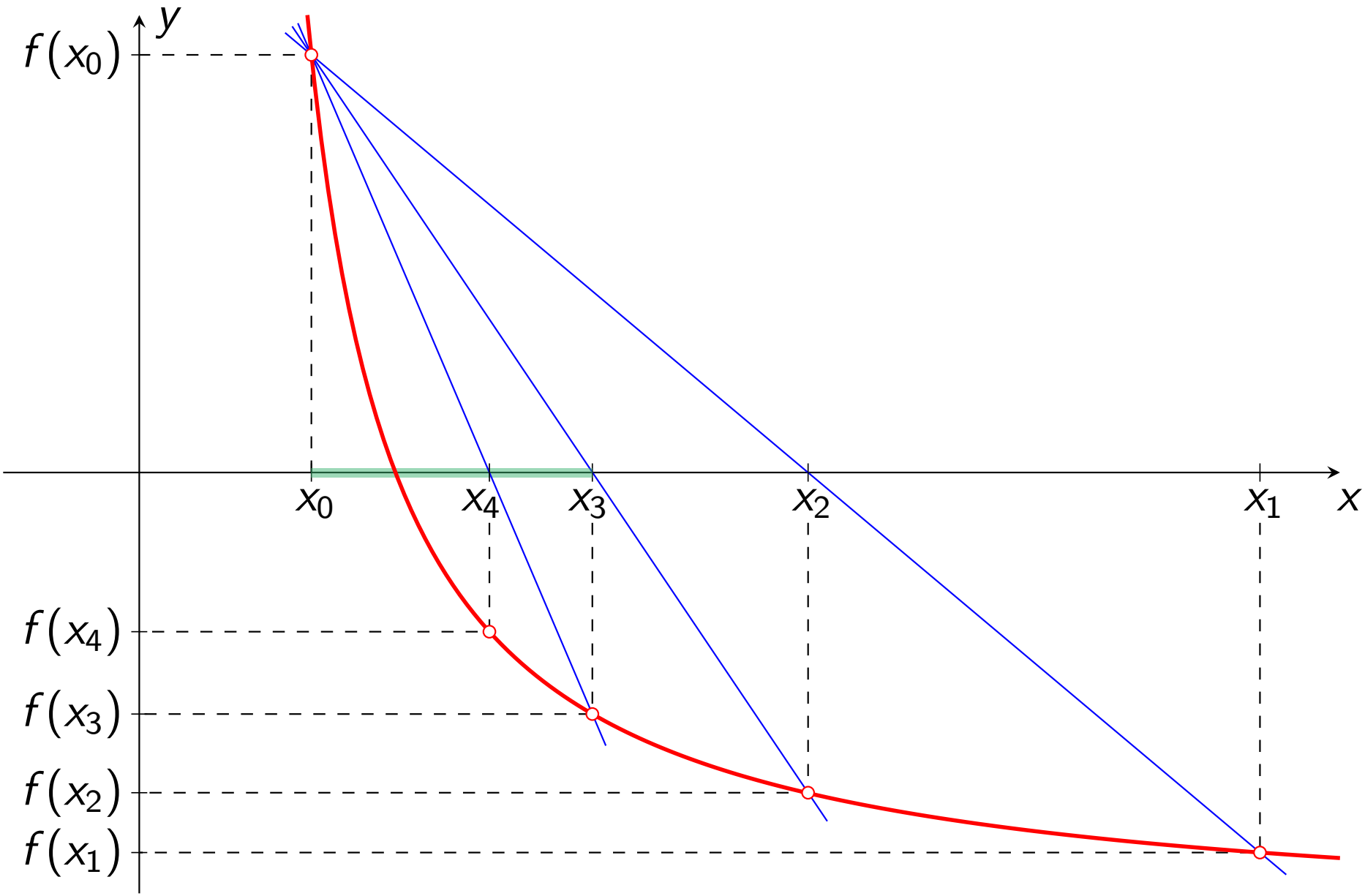

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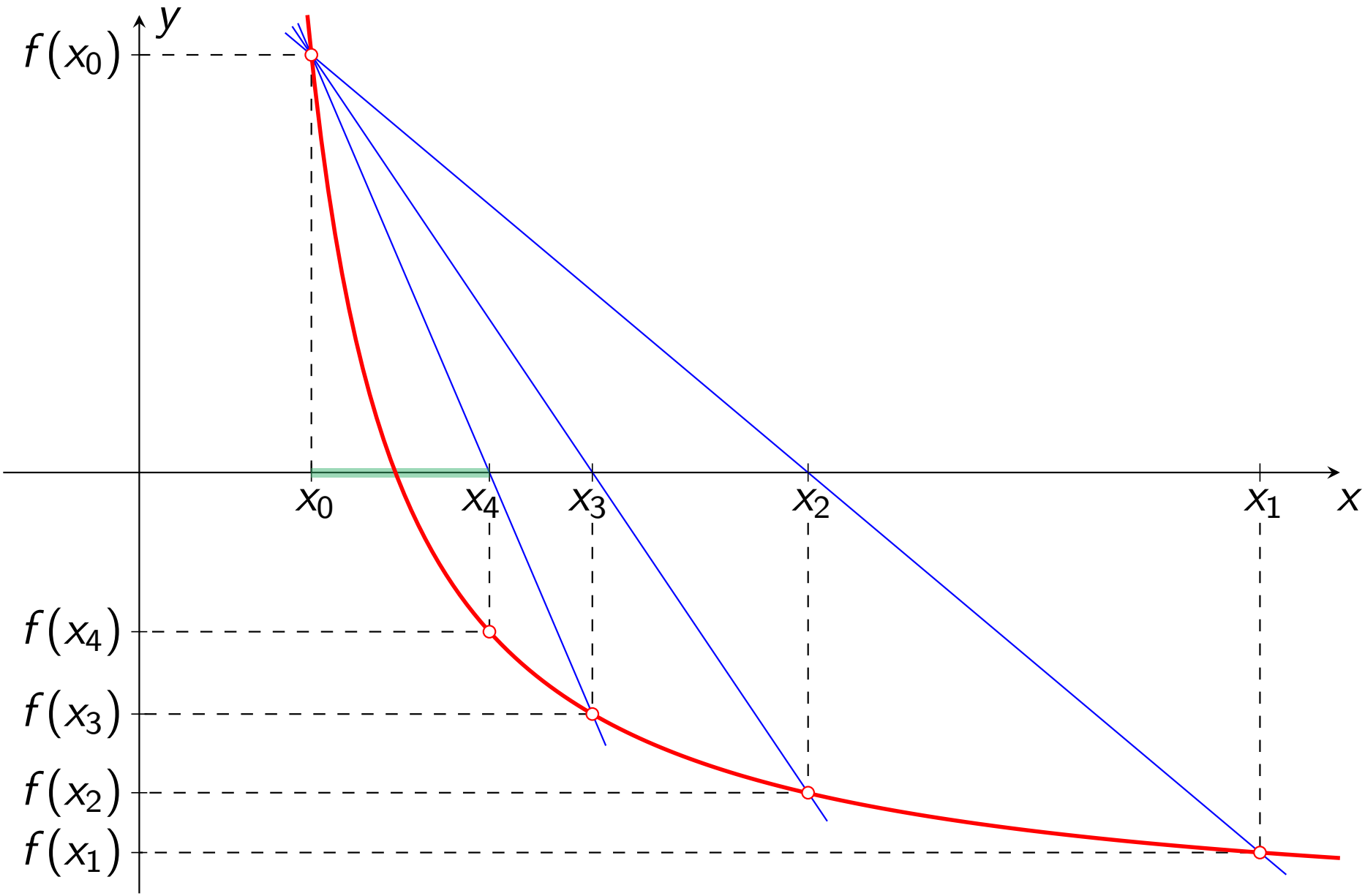

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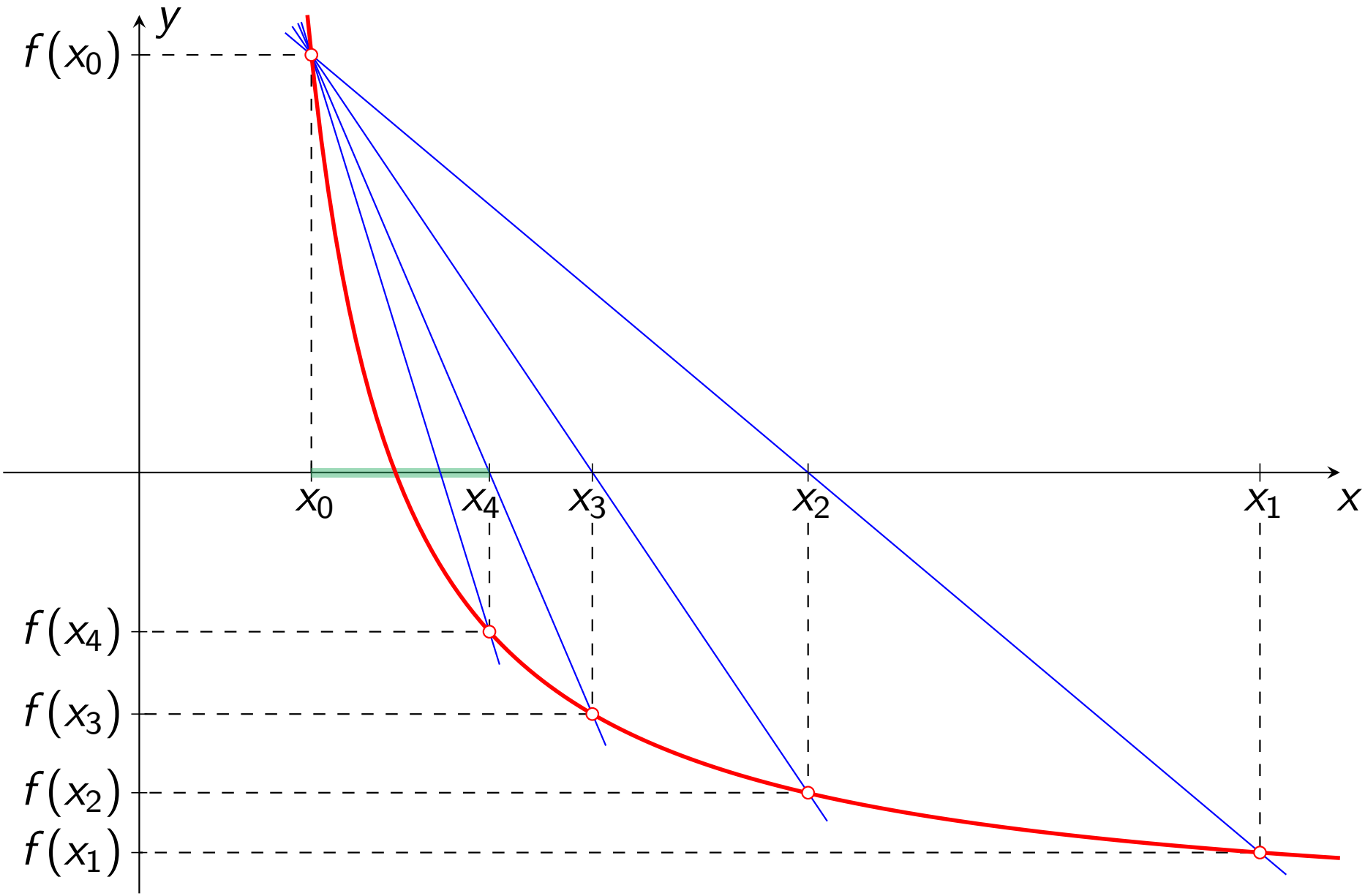

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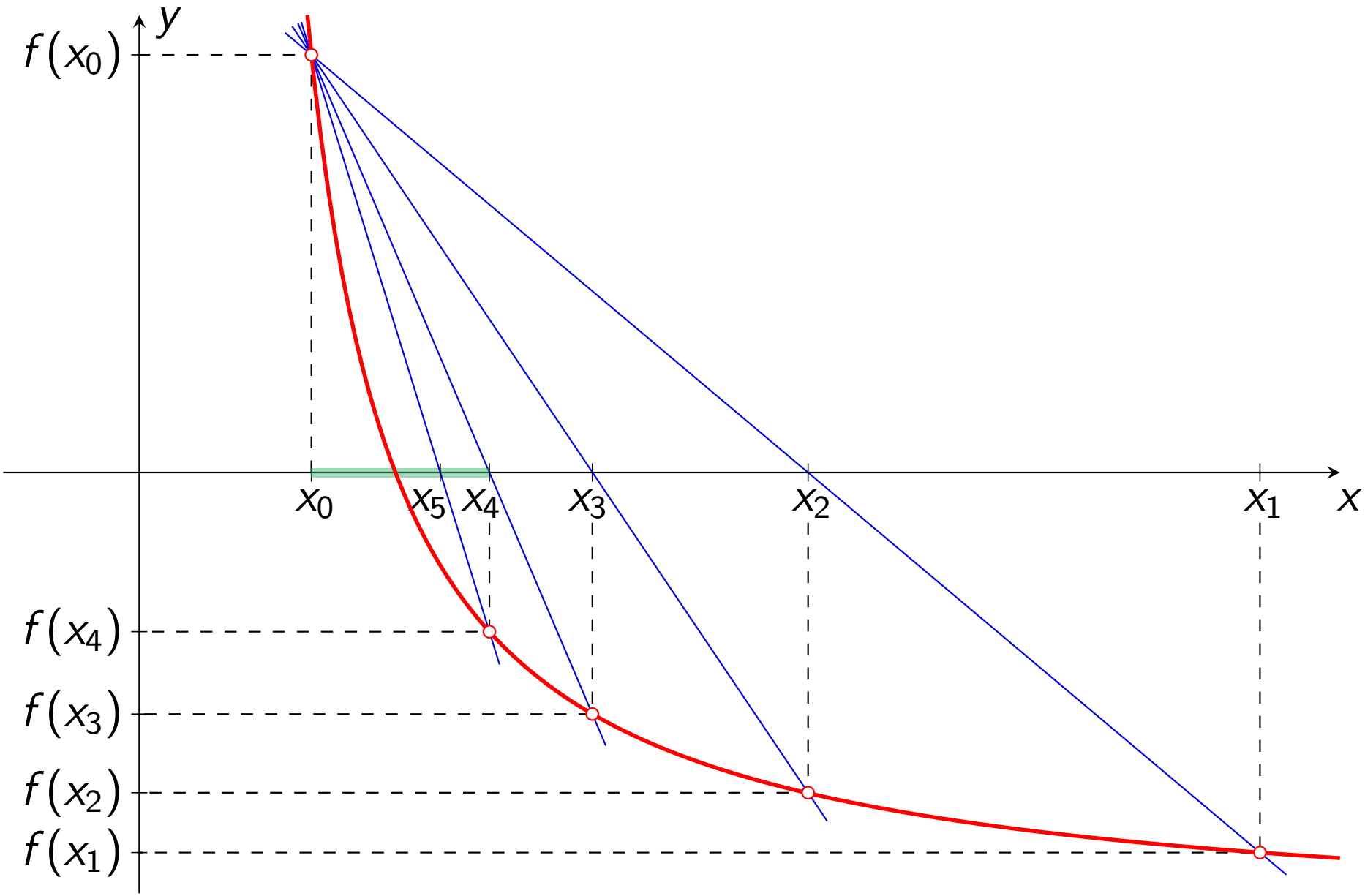

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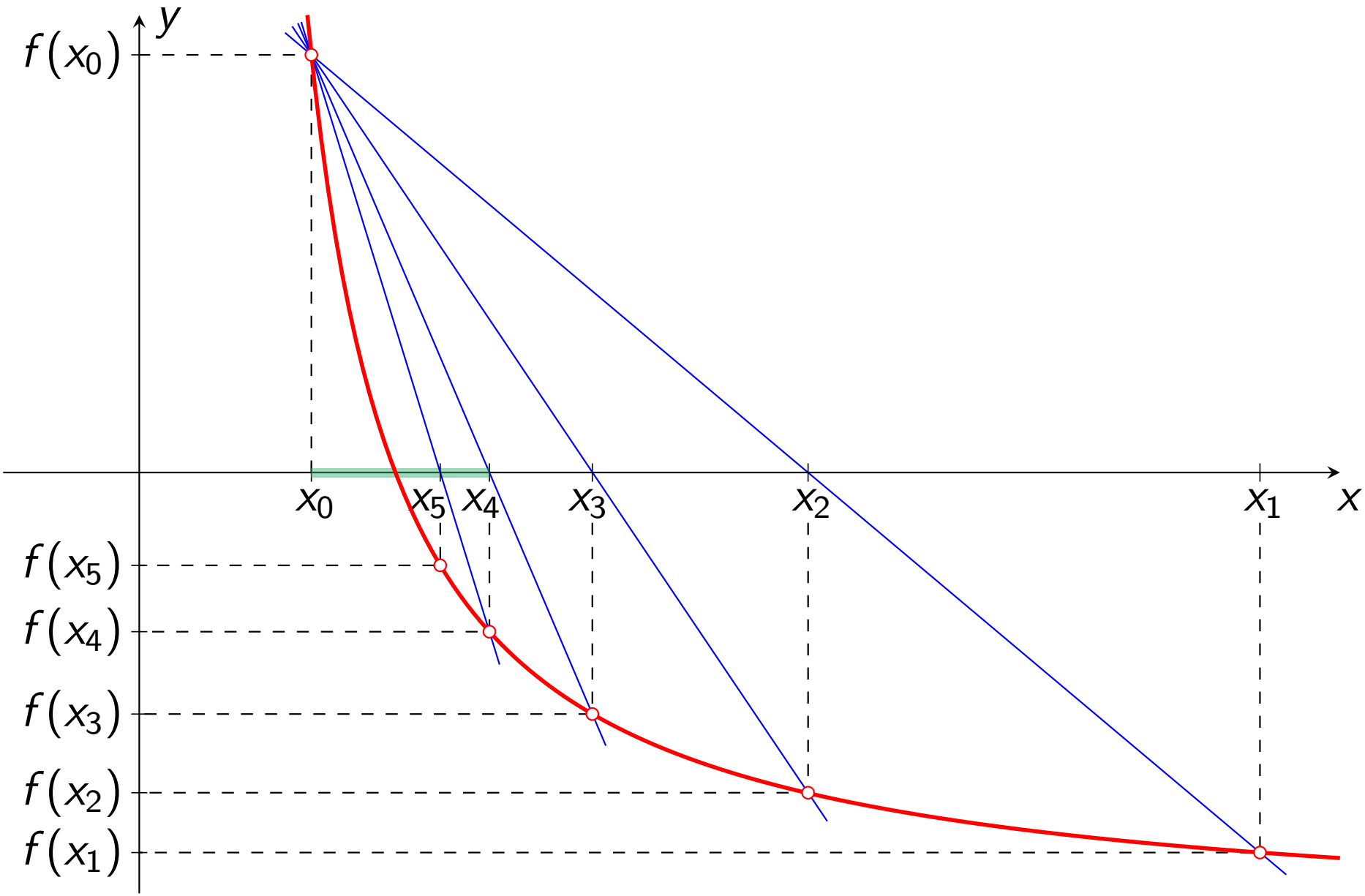

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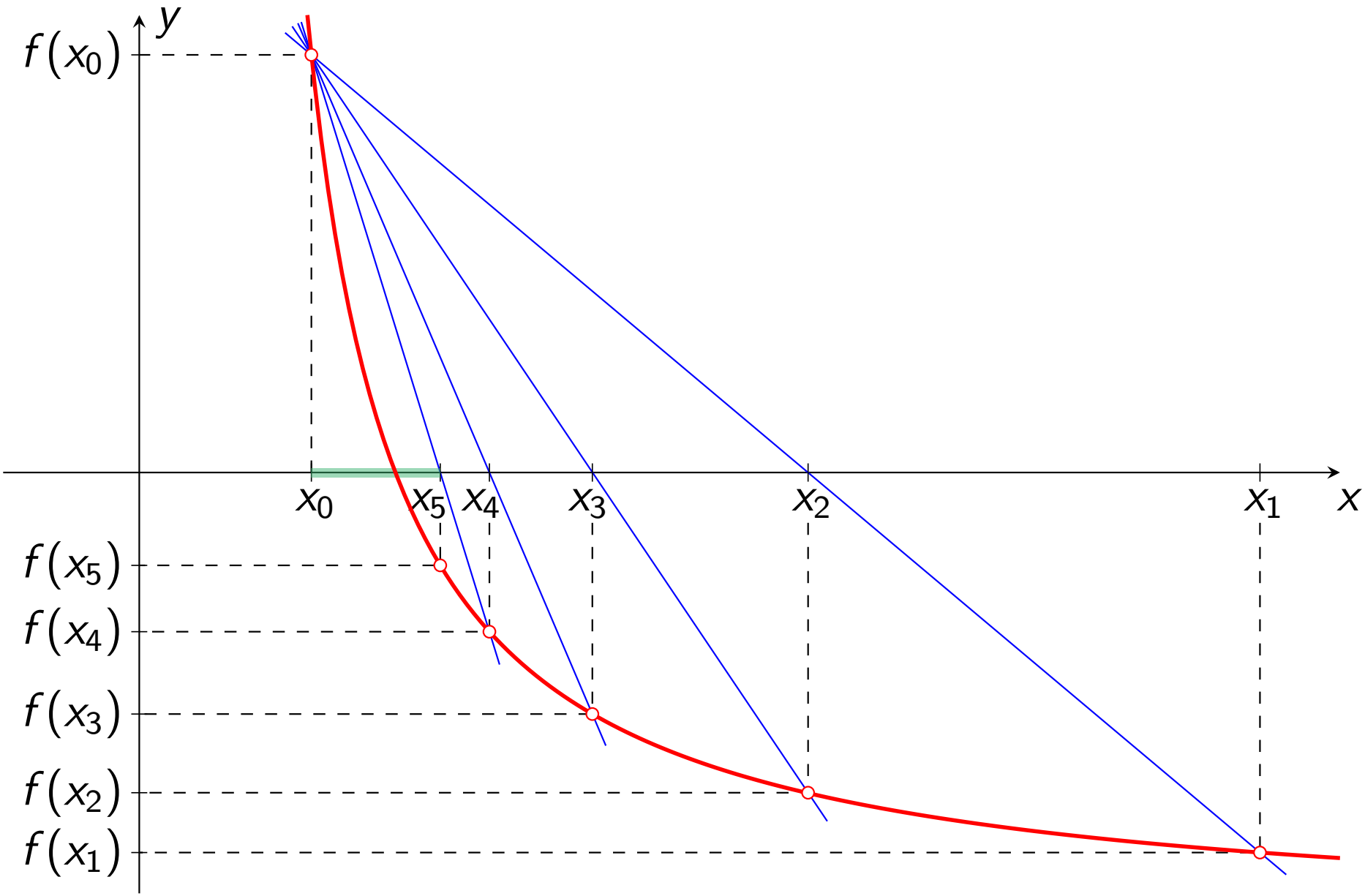

# Metoda Regula falsi

- Zadane točke: $\big(a, f(a)\big),\ \big(b, f(b)\big)$

# Metoda Regula falsi

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)$$

- Zadane točke: $\big(a, f(a)\big),\ \big(b, f(b)\big)$
- Jednadžba pravca kroz zadane točke

$$y - f(a) = \frac{f(b) - f(a)}{b - a}(x - a)$$

# Metoda Regula falsi

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)$$

- Zadane točke: $\big(a, f(a)\big),\ \big(b, f(b)\big)$
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$$y - f(a) = \frac{f(b) - f(a)}{b - a}(x - a)$$

- Tražimo presjek pravca s $x$-osi

# Metoda Regula falsi

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)$$

- Zadane točke: $\big(a, f(a)\big),\ \big(b, f(b)\big)$
- Jednadžba pravca kroz zadane točke

$$y - f(a) = \frac{f(b) - f(a)}{b - a}(x - a)$$

- Tražimo presjek pravca s $x$-osi

$y = 0$

# Metoda Regula falsi

$$-f(a) = \frac{f(b) - f(a)}{b - a}(x - a)$$

# Metoda Regula falsi

$$-f(a) = \frac{f(b) - f(a)}{b - a}(x - a)$$

$$\frac{f(b) - f(a)}{b - a} \cdot x = -f(a) + a \cdot \frac{f(b) - f(a)}{b - a}$$

# Metoda Regula falsi

$$-f(a) = \frac{f(b) - f(a)}{b - a}(x - a)$$

$$\frac{f(b) - f(a)}{b - a} \cdot x = -f(a) + a \cdot \frac{f(b) - f(a)}{b - a} \Big/ \cdot \frac{b - a}{f(b) - f(a)}$$

$$x = \frac{a \cdot f(a) - b \cdot f(a)}{f(b) - f(a)} + a$$

# Metoda Regula falsi

$$-f(a) = \frac{f(b) - f(a)}{b - a}(x - a)$$

$$\frac{f(b) - f(a)}{b - a} \cdot x = -f(a) + a \cdot \frac{f(b) - f(a)}{b - a} \Big/ \cdot \frac{b - a}{f(b) - f(a)}$$

$$x = \frac{a \cdot f(a) - b \cdot f(a)}{f(b) - f(a)} + a$$

$$x = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

**Algoritam:** Regula falsi

**Ulaz:** Neprekidna funkcija na intervalu $\langle a, b \rangle$ takva da je $f(a) \cdot f(b) < 0$.

**Izlaz:** Nultočka funkcije $f$ na intervalu $\langle a, b \rangle$ na zadanu točnost.

**while** *uvjet konvergencije nije istinit* **do**

    $c := \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$;

    **if** $f(a) \cdot f(c) < 0$ **then**

        $b := c$;

    **else**

        $a := c$;

    **end**

**end**

**return** $c$

# Uvjeti konvergencije

Neka je $c_i$ vrijednost broja $c$ dobivena u $i$-toj iteraciji.

- Petlju možemo prekinuti u trenutku kada je

$$\left|c_i - c_{i-1}\right| < \delta$$

  za neki unaprijed zadani mali broj $\delta > 0$.

- Ili, petlju možemo prekinuti u trenutku kada je

$$\left|f(c_i)\right| < \epsilon$$

  za neki unaprijed zadani mali broj $\epsilon > 0$.

- Također, iz sigurnosnih razloga u implementaciji ograničimo maksimalni broj iteracija u slučaju da niti jedan od gornja dva uvjeta ne bi mogao biti zadovoljen nakon razumnog broja iteracija.

# šesti zadatak

## Zadatak 6

*Banka mora odlučiti između dviju investicija u iznosu od* 200 000 € *čiji novčani tokovi su procijenjeni u sljedećoj tablici.*

| *godina* | 0. | 1. | 2. | 3. | 4. | 5. |
|---|---|---|---|---|---|---|
| *A* | −200 000 | 80 000 | 60 000 | 70 000 | 100 000 | 100 000 |
| *B* | −200 000 | 30 000 | 85 000 | 95 000 | 90 000 | 85 000 |

a) *Odredite NPV oba projekta uz cijenu kapitala* 7%.

b) *Približno odredite IRR oba projekta pomoću metode Regula falsi.*

## Rješenje

a)

| godina | 0. | 1. | 2. | 3. | 4. | 5. |
|---|---|---|---|---|---|---|
| A | −200 000 | 80 000 | 60 000 | 70 000 | 100 000 | 100 000 |
| B | −200 000 | 30 000 | 85 000 | 95 000 | 90 000 | 85 000 |

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3} + \frac{F_4}{r^4} + \frac{F_5}{r^5}$$

## Rješenje

a)

| godina | 0. | 1. | 2. | 3. | 4. | 5. |
|---|---|---|---|---|---|---|
| A | −200 000 | 80 000 | 60 000 | 70 000 | 100 000 | 100 000 |
| B | −200 000 | 30 000 | 85 000 | 95 000 | 90 000 | 85 000 |

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3} + \frac{F_4}{r^4} + \frac{F_5}{r^5}$$

$$NPV(A) = -200\,000 + \frac{80\,000}{1.07} + \frac{60\,000}{1.07^2} + \frac{70\,000}{1.07^3} + \frac{100\,000}{1.07^4} + \frac{100\,000}{1.07^5}$$

## Rješenje

a)

| godina | 0. | 1. | 2. | 3. | 4. | 5. |
|---|---|---|---|---|---|---|
| A | −200 000 | 80 000 | 60 000 | 70 000 | 100 000 | 100 000 |
| B | −200 000 | 30 000 | 85 000 | 95 000 | 90 000 | 85 000 |

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3} + \frac{F_4}{r^4} + \frac{F_5}{r^5}$$

$$NPV(A) = -200\,000 + \frac{80\,000}{1.07} + \frac{60\,000}{1.07^2} + \frac{70\,000}{1.07^3} + \frac{100\,000}{1.07^4} + \frac{100\,000}{1.07^5}$$

$$NPV(A) = 131\,901.67$$

## Rješenje

a)

| godina | 0. | 1. | 2. | 3. | 4. | 5. |
|---|---|---|---|---|---|---|
| A | $-200\,000$ | 80 000 | 60 000 | 70 000 | 100 000 | 100 000 |
| B | $-200\,000$ | 30 000 | 85 000 | 95 000 | 90 000 | 85 000 |

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3} + \frac{F_4}{r^4} + \frac{F_5}{r^5}$$

$$NPV(A) = -200\,000 + \frac{80\,000}{1.07} + \frac{60\,000}{1.07^2} + \frac{70\,000}{1.07^3} + \frac{100\,000}{1.07^4} + \frac{100\,000}{1.07^5}$$

$$NPV(A) = 131\,901.67$$

$$NPV(B) = -200\,000 + \frac{30\,000}{1.07} + \frac{85\,000}{1.07^2} + \frac{95\,000}{1.07^3} + \frac{90\,000}{1.07^4} + \frac{85\,000}{1.07^5}$$

## Rješenje

a)

| godina | 0. | 1. | 2. | 3. | 4. | 5. |
|---|---|---|---|---|---|---|
| A | −200 000 | 80 000 | 60 000 | 70 000 | 100 000 | 100 000 |
| B | −200 000 | 30 000 | 85 000 | 95 000 | 90 000 | 85 000 |

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3} + \frac{F_4}{r^4} + \frac{F_5}{r^5}$$

$$NPV(A) = -200\,000 + \frac{80\,000}{1.07} + \frac{60\,000}{1.07^2} + \frac{70\,000}{1.07^3} + \frac{100\,000}{1.07^4} + \frac{100\,000}{1.07^5}$$

$$NPV(A) = 131\,901.67$$

$$NPV(B) = -200\,000 + \frac{30\,000}{1.07} + \frac{85\,000}{1.07^2} + \frac{95\,000}{1.07^3} + \frac{90\,000}{1.07^4} + \frac{85\,000}{1.07^5}$$

$$NPV(B) = 109\,092.37$$

## Rješenje

a) Projekt $A$ je isplativiji jer je $NPV(A) > 0$ i $NPV(A) > NPV(B)$.

| godina | 0. | 1. | 2. | 3. | 4. | 5. |
|---|---|---|---|---|---|---|
| A | $-200\,000$ | $80\,000$ | $60\,000$ | $70\,000$ | $100\,000$ | $100\,000$ |
| B | $-200\,000$ | $30\,000$ | $85\,000$ | $95\,000$ | $90\,000$ | $85\,000$ |

$$NPV = F_0 + \frac{F_1}{r} + \frac{F_2}{r^2} + \frac{F_3}{r^3} + \frac{F_4}{r^4} + \frac{F_5}{r^5}$$

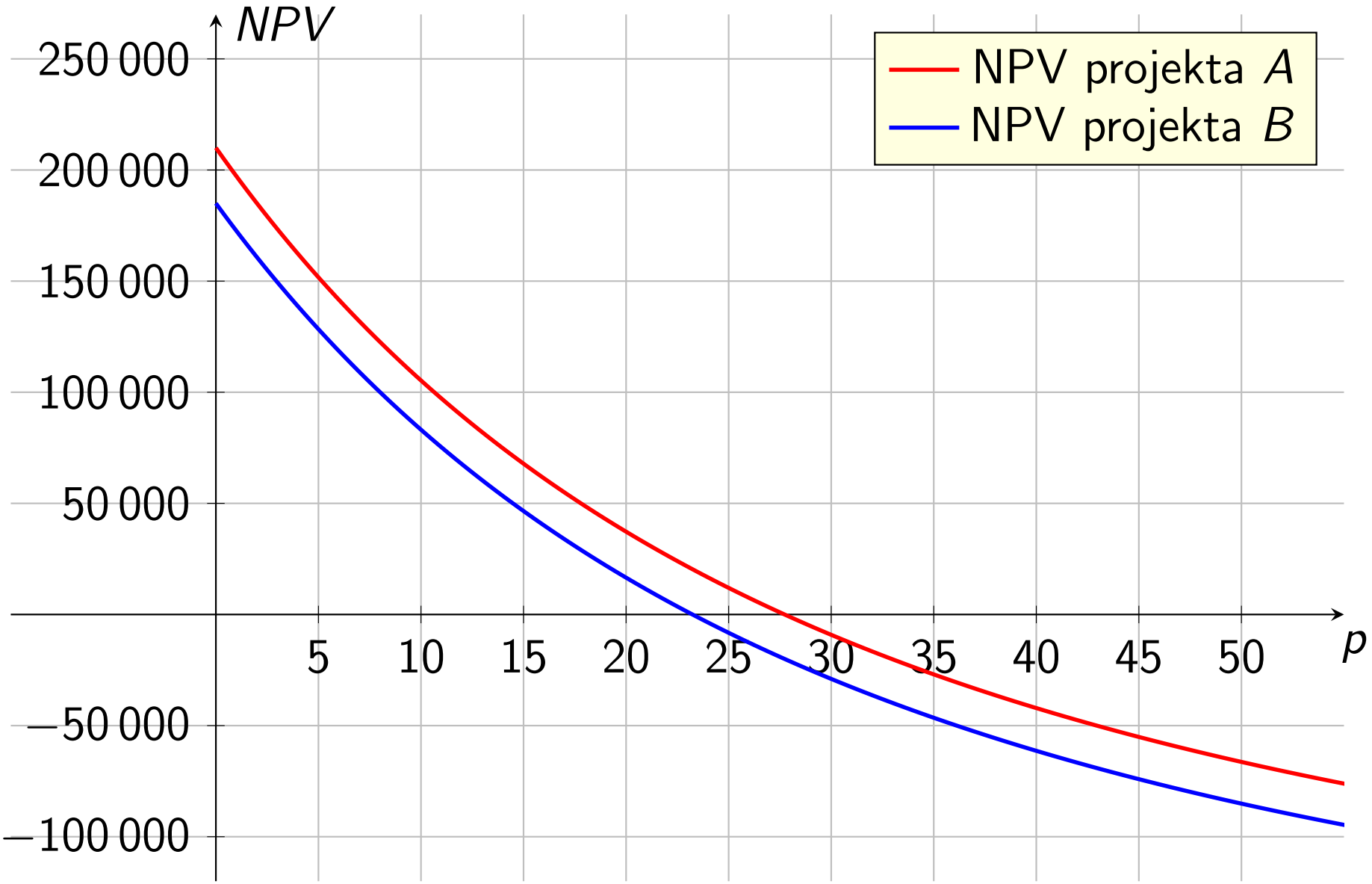
$$NPV(A) = -200\,000 + \frac{80\,000}{1.07} + \frac{60\,000}{1.07^2} + \frac{70\,000}{1.07^3} + \frac{100\,000}{1.07^4} + \frac{100\,000}{1.07^5}$$

$$NPV(A) = 131\,901.67$$

$$NPV(B) = -200\,000 + \frac{30\,000}{1.07} + \frac{85\,000}{1.07^2} + \frac{95\,000}{1.07^3} + \frac{90\,000}{1.07^4} + \frac{85\,000}{1.07^5}$$

$$NPV(B) = 109\,092.37$$

# NPV projekata $A$ i $B$ kao funkcija cijene kapitala



b) $$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | $NPV_A$ |
|---|---|
| 25% | |
| 30% | |
| | |
| | |
| | |
| | |

b) $$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | $NPV_A$ |
|---|---|
| 25% | |
| 30% | |
| | |
| | |
| | |
| | |

$$NPV_A(25) = -200\,000 + \frac{80\,000}{1.25} + \frac{60\,000}{1.25^2} +$$

$$+ \frac{70\,000}{1.25^3} + \frac{100\,000}{1.25^4} + \frac{100\,000}{1.25^5}$$

b) $$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | |
| | |
| | |
| | |
| | |

$$NPV_A(25) = -200\,000 + \frac{80\,000}{1.25} + \frac{60\,000}{1.25^2} +$$

$$+ \frac{70\,000}{1.25^3} + \frac{100\,000}{1.25^4} + \frac{100\,000}{1.25^5}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | |
| | |
| | |
| | |
| | |

$$NPV_A(30) = -200\,000 + \frac{80\,000}{1.3} + \frac{60\,000}{1.3^2} +$$
$$+ \frac{70\,000}{1.3^3} + \frac{100\,000}{1.3^4} + \frac{100\,000}{1.3^5}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| | |
| | |
| | |
| | |

$$NPV_A(30) = -200\,000 + \frac{80\,000}{1.3} + \frac{60\,000}{1.3^2} +$$
$$+ \frac{70\,000}{1.3^3} + \frac{100\,000}{1.3^4} + \frac{100\,000}{1.3^5}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| | |
| | |
| | |
| | |

$$c_1 = \frac{25 \cdot NPV_A(30) - 30 \cdot NPV_A(25)}{NPV_A(30) - NPV_A(25)}$$

b) $$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | 27.83343 |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| | |
| | |
| | |
| | |

$$c_1 = \frac{25 \cdot NPV_A(30) - 30 \cdot NPV_A(25)}{NPV_A(30) - NPV_A(25)}$$

b) $$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | 27.83343 |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| 27.83343% | |
| | |
| | |
| | |

$$NPV_A(27.83343) = -200\,000 + \frac{80\,000}{1.2783343} + \frac{60\,000}{1.2783343^2} +$$

$$+ \frac{70\,000}{1.2783343^3} + \frac{100\,000}{1.2783343^4} + \frac{100\,000}{1.2783343^5}$$

b) $$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | 27.83343 |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| 27.83343% | − 451.33 |
| | |
| | |
| | |

$$NPV_A(27.83343) = -200\,000 + \frac{80\,000}{1.2783343} + \frac{60\,000}{1.2783343^2} +$$

$$+ \frac{70\,000}{1.2783343^3} + \frac{100\,000}{1.2783343^4} + \frac{100\,000}{1.2783343^5}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | 27.83343 |
| 2 | 25 | 27.83343 | |
| 3 | | | |
| 4 | | | |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| 27.83343% | − 451.33 |
| | |
| | |
| | |

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | 27.83343 |
| 2 | 25 | 27.83343 | |
| 3 | | | |
| 4 | | | |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| 27.83343% | − 451.33 |
| | |
| | |
| | |

$$c_2 = \frac{25 \cdot NPV_A(27.83343) - 27.83343 \cdot NPV_A(25)}{NPV_A(27.83343) - NPV_A(25)}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | 27.83343 |
| 2 | 25 | 27.83343 | 27.73046 |
| 3 | | | |
| 4 | | | |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| 27.83343% | − 451.33 |
| | |
| | |
| | |

$$c_2 = \frac{25 \cdot NPV_A(27.83343) - 27.83343 \cdot NPV_A(25)}{NPV_A(27.83343) - NPV_A(25)}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | 27.83343 |
| 2 | 25 | 27.83343 | 27.73046 |
| 3 | | | |
| 4 | | | |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| 27.83343% | − 451.33 |
| 27.73046% | |
| | |
| | |

$$NPV_A(27.73046) = -200\,000 + \frac{80\,000}{1.2773046} + \frac{60\,000}{1.2773046^2} +$$

$$+ \frac{70\,000}{1.2773046^3} + \frac{100\,000}{1.2773046^4} + \frac{100\,000}{1.2773046^5}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | 27.83343 |
| 2 | 25 | 27.83343 | 27.73046 |
| 3 | | | |
| 4 | | | |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| 27.83343% | − 451.33 |
| 27.73046% | − 21.39 |
| | |
| | |

$$NPV_A(27.73046) = -200\,000 + \frac{80\,000}{1.2773046} + \frac{60\,000}{1.2773046^2} +$$

$$+ \frac{70\,000}{1.2773046^3} + \frac{100\,000}{1.2773046^4} + \frac{100\,000}{1.2773046^5}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | 27.83343 |
| 2 | 25 | 27.83343 | 27.73046 |
| 3 | 25 | 27.73046 | |
| 4 | | | |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| 27.83343% | − 451.33 |
| 27.73046% | − 21.39 |
| | |
| | |

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | 27.83343 |
| 2 | 25 | 27.83343 | 27.73046 |
| 3 | 25 | 27.73046 | |
| 4 | | | |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| 27.83343% | − 451.33 |
| 27.73046% | − 21.39 |
| | |
| | |

$$c_3 = \frac{25 \cdot NPV_A(27.73046) - 27.73046 \cdot NPV_A(25)}{NPV_A(27.73046) - NPV_A(25)}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | 27.83343 |
| 2 | 25 | 27.83343 | 27.73046 |
| 3 | 25 | 27.73046 | 27.72559 |
| 4 | | | |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| 27.83343% | − 451.33 |
| 27.73046% | − 21.39 |
| | |
| | |

$$c_3 = \frac{25 \cdot NPV_A(27.73046) - 27.73046 \cdot NPV_A(25)}{NPV_A(27.73046) - NPV_A(25)}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | 27.83343 |
| 2 | 25 | 27.83343 | 27.73046 |
| 3 | 25 | 27.73046 | 27.72559 |
| 4 | | | |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| 27.83343% | − 451.33 |
| 27.73046% | − 21.39 |
| 27.72559% | |
| | |

$$NPV_A(27.72559) = -200\,000 + \frac{80\,000}{1.2772559} + \frac{60\,000}{1.2772559^2} +$$

$$+ \frac{70\,000}{1.2772559^3} + \frac{100\,000}{1.2772559^4} + \frac{100\,000}{1.2772559^5}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | 27.83343 |
| 2 | 25 | 27.83343 | 27.73046 |
| 3 | 25 | 27.73046 | 27.72559 |
| 4 | | | |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| 27.83343% | − 451.33 |
| 27.73046% | − 21.39 |
| 27.72559% | − 1.01 |
| | |

$$NPV_A(27.72559) = -200\,000 + \frac{80\,000}{1.2772559} + \frac{60\,000}{1.2772559^2} +$$
$$+ \frac{70\,000}{1.2772559^3} + \frac{100\,000}{1.2772559^4} + \frac{100\,000}{1.2772559^5}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | 27.83343 |
| 2 | 25 | 27.83343 | 27.73046 |
| 3 | 25 | 27.73046 | 27.72559 |
| 4 | 25 | 27.72559 | |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| 27.83343% | − 451.33 |
| 27.73046% | − 21.39 |
| 27.72559% | − 1.01 |
| | |

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | 27.83343 |
| 2 | 25 | 27.83343 | 27.73046 |
| 3 | 25 | 27.73046 | 27.72559 |
| 4 | 25 | 27.72559 | |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| 27.83343% | − 451.33 |
| 27.73046% | − 21.39 |
| 27.72559% | − 1.01 |
| | |

$$c_4 = \frac{25 \cdot NPV_A(27.72559) - 27.72559 \cdot NPV_A(25)}{NPV_A(27.72559) - NPV_A(25)}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | 27.83343 |
| 2 | 25 | 27.83343 | 27.73046 |
| 3 | 25 | 27.73046 | 27.72559 |
| 4 | 25 | 27.72559 | 27.72536 |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| 27.83343% | − 451.33 |
| 27.73046% | − 21.39 |
| 27.72559% | − 1.01 |
| | |

$$c_4 = \frac{25 \cdot NPV_A(27.72559) - 27.72559 \cdot NPV_A(25)}{NPV_A(27.72559) - NPV_A(25)}$$

b) $$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | 27.83343 |
| 2 | 25 | 27.83343 | 27.73046 |
| 3 | 25 | 27.73046 | 27.72559 |
| 4 | 25 | 27.72559 | 27.72536 |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| 27.83343% | − 451.33 |
| 27.73046% | − 21.39 |
| 27.72559% | − 1.01 |
| 27.72536% | |

$$NPV_A(27.72536) = -200\,000 + \frac{80\,000}{1.2772536} + \frac{60\,000}{1.2772536^2} +$$

$$+ \frac{70\,000}{1.2772536^3} + \frac{100\,000}{1.2772536^4} + \frac{100\,000}{1.2772536^5}$$

b) $$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | 27.83343 |
| 2 | 25 | 27.83343 | 27.73046 |
| 3 | 25 | 27.73046 | 27.72559 |
| 4 | 25 | 27.72559 | 27.72536 |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| 27.83343% | − 451.33 |
| 27.73046% | − 21.39 |
| 27.72559% | − 1.01 |
| 27.72536% | − 0.05 |

$$NPV_A(27.72536) = -200\,000 + \frac{80\,000}{1.2772536} + \frac{60\,000}{1.2772536^2} +$$

$$+ \frac{70\,000}{1.2772536^3} + \frac{100\,000}{1.2772536^4} + \frac{100\,000}{1.2772536^5}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 25 | 30 | 27.83343 |
| 2 | 25 | 27.83343 | 27.73046 |
| 3 | 25 | 27.73046 | 27.72559 |
| 4 | 25 | 27.72559 | 27.72536 |

| | $NPV_A$ |
|---|---|
| 25% | 11968 |
| 30% | − 9151.26 |
| 27.83343% | − 451.33 |
| 27.73046% | − 21.39 |
| 27.72559% | − 1.01 |
| 27.72536% | − 0.05 |

$$IRR(A) = 27.72536\%$$

b)

$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | $NPV_B$ |
|---|---|
| 20% | |
| 25% | |
| | |
| | |
| | |
| | |

b)

$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | $NPV_B$ |
|---|---|
| 20% | |
| 25% | |
| | |
| | |
| | |
| | |

$$NPV_B(20) = -200\,000 + \frac{30\,000}{1.2} + \frac{85\,000}{1.2^2} +$$

$$+ \frac{95\,000}{1.2^3} + \frac{90\,000}{1.2^4} + \frac{85\,000}{1.2^5}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | |
| | |
| | |
| | |
| | |

$$NPV_B(20) = -200\,000 + \frac{30\,000}{1.2} + \frac{85\,000}{1.2^2} +$$
$$+ \frac{95\,000}{1.2^3} + \frac{90\,000}{1.2^4} + \frac{85\,000}{1.2^5}$$

b) $$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | |
| | |
| | |
| | |
| | |

$$NPV_B(25) = -200\,000 + \frac{30\,000}{1.25} + \frac{85\,000}{1.25^2} +$$

$$+ \frac{95\,000}{1.25^3} + \frac{90\,000}{1.25^4} + \frac{85\,000}{1.25^5}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| | |
| | |
| | |
| | |

$$NPV_B(25) = -200\,000 + \frac{30\,000}{1.25} + \frac{85\,000}{1.25^2} +$$
$$+ \frac{95\,000}{1.25^3} + \frac{90\,000}{1.25^4} + \frac{85\,000}{1.25^5}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| | |
| | |
| | |
| | |

$$c_1 = \frac{20 \cdot NPV_B(25) - 25 \cdot NPV_B(20)}{NPV_B(25) - NPV_B(20)}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | 23.33875 |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| | |
| | |
| | |
| | |

$$c_1 = \frac{20 \cdot NPV_B(25) - 25 \cdot NPV_B(20)}{NPV_B(25) - NPV_B(20)}$$

b) $$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | 23.33875 |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| 23.33875% | |
| | |
| | |
| | |

$$NPV_B(23.33875) = -200\,000 + \frac{30\,000}{1.2333875} + \frac{85\,000}{1.2333875^2} +$$

$$+ \frac{95\,000}{1.2333875^3} + \frac{90\,000}{1.2333875^4} + \frac{85\,000}{1.2333875^5}$$

b) $$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | 23.33875 |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| 23.33875% | − 499.13 |
| | |
| | |
| | |

$$NPV_B(23.33875) = -200\,000 + \frac{30\,000}{1.2333875} + \frac{85\,000}{1.2333875^2} +$$

$$+ \frac{95\,000}{1.2333875^3} + \frac{90\,000}{1.2333875^4} + \frac{85\,000}{1.2333875^5}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | 23.33875 |
| 2 | 20 | 23.33875 | |
| 3 | | | |
| 4 | | | |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| 23.33875% | − 499.13 |
| | |
| | |
| | |

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | 23.33875 |
| 2 | 20 | 23.33875 | |
| 3 | | | |
| 4 | | | |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| 23.33875% | − 499.13 |
| | |
| | |
| | |

$$c_2 = \frac{20 \cdot NPV_B(23.33875) - 23.33875 \cdot NPV_B(20)}{NPV_B(23.33875) - NPV_B(20)}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | 23.33875 |
| 2 | 20 | 23.33875 | 23.2411 |
| 3 | | | |
| 4 | | | |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| 23.33875% | − 499.13 |
| | |
| | |
| | |

$$c_2 = \frac{20 \cdot NPV_B(23.33875) - 23.33875 \cdot NPV_B(20)}{NPV_B(23.33875) - NPV_B(20)}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | 23.33875 |
| 2 | 20 | 23.33875 | 23.2411 |
| 3 | | | |
| 4 | | | |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| 23.33875% | − 499.13 |
| 23.2411% | |
| | |
| | |

$$NPV_B(23.2411) = -200\,000 + \frac{30\,000}{1.232411} + \frac{85\,000}{1.232411^2} +$$

$$+ \frac{95\,000}{1.232411^3} + \frac{90\,000}{1.232411^4} + \frac{85\,000}{1.232411^5}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | 23.33875 |
| 2 | 20 | 23.33875 | 23.2411 |
| 3 | | | |
| 4 | | | |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| 23.33875% | − 499.13 |
| 23.2411% | − 29.25 |
| | |
| | |

$$NPV_B(23.2411) = -200\,000 + \frac{30\,000}{1.232411} + \frac{85\,000}{1.232411^2} +$$

$$+ \frac{95\,000}{1.232411^3} + \frac{90\,000}{1.232411^4} + \frac{85\,000}{1.232411^5}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | 23.33875 |
| 2 | 20 | 23.33875 | 23.2411 |
| 3 | 20 | 23.2411 | |
| 4 | | | |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| 23.33875% | − 499.13 |
| 23.2411% | − 29.25 |
| | |
| | |

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | 23.33875 |
| 2 | 20 | 23.33875 | 23.2411 |
| 3 | 20 | 23.2411 | |
| 4 | | | |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| 23.33875% | − 499.13 |
| 23.2411% | − 29.25 |
| | |
| | |

$$c_3 = \frac{20 \cdot NPV_B(23.2411) - 23.2411 \cdot NPV_B(20)}{NPV_B(23.2411) - NPV_B(20)}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | 23.33875 |
| 2 | 20 | 23.33875 | 23.2411 |
| 3 | 20 | 23.2411 | 23.23539 |
| 4 | | | |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| 23.33875% | − 499.13 |
| 23.2411% | − 29.25 |
| | |
| | |

$$c_3 = \frac{20 \cdot NPV_B(23.2411) - 23.2411 \cdot NPV_B(20)}{NPV_B(23.2411) - NPV_B(20)}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | 23.33875 |
| 2 | 20 | 23.33875 | 23.2411 |
| 3 | 20 | 23.2411 | 23.23539 |
| 4 | | | |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| 23.33875% | − 499.13 |
| 23.2411% | − 29.25 |
| 23.23539% | |
| | |

$$NPV_B(23.23539) = -200\,000 + \frac{30\,000}{1.2323539} + \frac{85\,000}{1.2323539^2} +$$

$$+ \frac{95\,000}{1.2323539^3} + \frac{90\,000}{1.2323539^4} + \frac{85\,000}{1.2323539^5}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | 23.33875 |
| 2 | 20 | 23.33875 | 23.2411 |
| 3 | 20 | 23.2411 | 23.23539 |
| 4 | | | |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| 23.33875% | − 499.13 |
| 23.2411% | − 29.25 |
| 23.23539% | − 1.72 |
| | |

$$NPV_B(23.23539) = -200\,000 + \frac{30\,000}{1.2323539} + \frac{85\,000}{1.2323539^2} +$$

$$+ \frac{95\,000}{1.2323539^3} + \frac{90\,000}{1.2323539^4} + \frac{85\,000}{1.2323539^5}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | 23.33875 |
| 2 | 20 | 23.33875 | 23.2411 |
| 3 | 20 | 23.2411 | 23.23539 |
| 4 | 20 | 23.23539 | |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| 23.33875% | − 499.13 |
| 23.2411% | − 29.25 |
| 23.23539% | − 1.72 |
| | |

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | 23.33875 |
| 2 | 20 | 23.33875 | 23.2411 |
| 3 | 20 | 23.2411 | 23.23539 |
| 4 | 20 | 23.23539 | |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| 23.33875% | − 499.13 |
| 23.2411% | − 29.25 |
| 23.23539% | − 1.72 |
| | |

$$c_4 = \frac{20 \cdot NPV_B(23.23539) - 23.23539 \cdot NPV_B(20)}{NPV_B(23.23539) - NPV_B(20)}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | 23.33875 |
| 2 | 20 | 23.33875 | 23.2411 |
| 3 | 20 | 23.2411 | 23.23539 |
| 4 | 20 | 23.23539 | 23.23505 |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| 23.33875% | − 499.13 |
| 23.2411% | − 29.25 |
| 23.23539% | − 1.72 |
| | |

$$c_4 = \frac{20 \cdot NPV_B(23.23539) - 23.23539 \cdot NPV_B(20)}{NPV_B(23.23539) - NPV_B(20)}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | 23.33875 |
| 2 | 20 | 23.33875 | 23.2411 |
| 3 | 20 | 23.2411 | 23.23539 |
| 4 | 20 | 23.23539 | 23.23505 |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| 23.33875% | − 499.13 |
| 23.2411% | − 29.25 |
| 23.23539% | − 1.72 |
| 23.23505% | |

$$NPV_B(23.23505) = -200\,000 + \frac{30\,000}{1.2323505} + \frac{85\,000}{1.2323505^2} +$$

$$+ \frac{95\,000}{1.2323505^3} + \frac{90\,000}{1.2323505^4} + \frac{85\,000}{1.2323505^5}$$

b) $$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | 23.33875 |
| 2 | 20 | 23.33875 | 23.2411 |
| 3 | 20 | 23.2411 | 23.23539 |
| 4 | 20 | 23.23539 | 23.23505 |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| 23.33875% | − 499.13 |
| 23.2411% | − 29.25 |
| 23.23539% | − 1.72 |
| 23.23505% | − 0.08 |

$$NPV_B(23.23505) = -200\,000 + \frac{30\,000}{1.2323505} + \frac{85\,000}{1.2323505^2} +$$

$$+ \frac{95\,000}{1.2323505^3} + \frac{90\,000}{1.2323505^4} + \frac{85\,000}{1.2323505^5}$$

b)
$$c = \frac{a \cdot f(b) - b \cdot f(a)}{f(b) - f(a)}$$

| $i$ | $a$ | $b$ | $c_i$ |
|---|---|---|---|
| 1 | 20 | 25 | 23.33875 |
| 2 | 20 | 23.33875 | 23.2411 |
| 3 | 20 | 23.2411 | 23.23539 |
| 4 | 20 | 23.23539 | 23.23505 |

| | $NPV_B$ |
|---|---|
| 20% | 16567 |
| 25% | − 8243.2 |
| 23.33875% | − 499.13 |
| 23.2411% | − 29.25 |
| 23.23539% | − 1.72 |
| 23.23505% | − 0.08 |

$$IRR(B) = 23.23505\%$$

# Efektivna kamatna stopa kod kredita

# Odluka o efektivnoj kamatnoj stopi kreditnih institucija i kreditnih unija te ugovaranju usluga s potrošačima (HNB 2009)

- **Odlukom o jedinstvenom iskazivanju efektivne kamatne stope** na kredite kreditne unije Hrvatska narodna banka propisuje način iskazivanja efektivne kamatne stope.
- Ovom odlukom izračunavanje efektivne kamatne stope i predočavanje javnosti i klijentu postaje **dužnost kreditora**.
- Efektivna kamatna stopa iskazuje se dvjema decimalama, uz zaokruživanje na dvije decimale.
- Ugovor o kreditu mora sadržavati odgovarajuću odredbu iz koje je razvidno da je **klijent upoznat s kreditnim uvjetima i efektivnom kamatnom stopom te da mu je uručena otplatna tablica**.

# Efektivna kamatna stopa

- Osnovu jedinstvenog načina izračunavanja efektivne kamatne stope na kredite i depozite čine **složeni kamatni račun** i **dekurzivni obračun kamata**.
- Jedinstveni način izračunavanja efektivne kamatne stope temelji se na **metodi neto sadašnje vrijednosti**.

# Efektivna kamatna stopa

- **Efektivna kamatna stopa** je kamatna stopa primjenom koje se diskontirani novčani primici izjenačuju s diskontiranim novčanim izdacima koji se odnose na odobrene kredite, odnosno primljene depozite, tj. ona kamatna stopa primjenom koje se diskontirana serija neto novčanih tokova izjednačuje s nulom.
- **Novčani tokovi** uključuju svaki novčani transfer između korisnika kredita i davatelja kredita koji je izravno vezan uz odobrenje kredita, odnosno koji je dio uvjeta korištenja kredita (npr. isplata glavnice, uplata anuiteta, jednokratna provizija za odobrenje kredita, periodična naknada za servisiranje kredita i sl.) ili koji uvjetuje odobravanje kredita (npr. naknada za obradu kreditnog zahtjeva).

# Matematička podloga za izračunavanje EKS

Efektivna kamatna stopa je razlika izmedu zbroja konačnih vrijednosti uplata davatelju kredita, odnosno primatelju depozita, i zbroja početnih vrijednosti isplata korisniku kredita, tj. deponentu, iskazana kao postotak od zbroja početnih vrijednosti isplata korisniku kredita, tj. deponentu, izražena na godišnjoj razini.

EKS je definiran sljedećim matematičkim izrazom

$$e = 100 \left[ \left( 1 + \frac{e_n}{100} \right)^{\frac{t}{n}} - 1 \right]$$

gdje je

$$e_n = 100 \cdot \frac{\sum_k BV_n(NT_k+) - \sum_k SV_0(NT_k-)}{\sum_k SV_0(NT_k-)} =$$

$$= 100 \cdot \left( \frac{\sum_k BV_n(NT_k+)}{\sum_k SV_0(NT_k-)} - 1 \right) =$$

$$= 100 \cdot \left( \frac{\sum_k (NT_k+)(1 + \frac{e_1}{100})^{n-d_k}}{\sum_k (NT_k-)(1 + \frac{e_1}{100})^{-d_k}} - 1 \right)$$

$$e_1 = 100 \left[ \left( 1 + \frac{e_n}{100} \right)^{\frac{1}{n}} - 1 \right]$$

- $e$ – EKS
- $e_n$ – EKS izražena na razini $n$ dana trajanja kredita
- $e_1$ – EKS izražena na razini jednog dana
- $t$ – broj dana u godini (ovisno o metodi računanja dana)
- $n$ – ukupni broj dana trajanja kredita
- $(NT_k-)$ – zbroj isplata korisniku kredita tijekom $k$-tog dana (negativni novčani tok)
- $(NT_k+)$ – zbroj uplata davatelju kredita tijekom $k$-tog dana (pozitivni novčani tok)
- $BV_n(x)$ – buduća vrijednost iznosa $x$ na kraju $n$-tog dana
- $SV_0(x)$ – sadašnja vrijednost iznosa $x$ na kraju nultog dana
- $d_k$ – broj proteklih dana od 0-tog dana do novčanog toka na $k$-ti promatrani dan

Vrijedi

$$1 + \frac{e_1}{100} = \left(1 + \frac{e_n}{100}\right)^{\frac{1}{n}} = \left(1 + \frac{e}{100}\right)^{\frac{1}{t}}.$$

Može se pokazati da vrijedi

$$\sum_k NNT_k \cdot \left(1 + \frac{e}{100}\right)^{-\frac{d_k}{t}} = 0$$

gdje je

$$NNT_k = (NT_k+) - (NT_k-).$$

# EKS kod kredita

- Napraviti otplatnu tablicu: izračunati anuitet, kamate, otplatne kvote i ostatke duga.

- Odrediti neto novčane tokove $NNT_k$ i diskontirane neto novčane tokove $DNNT_k$.

  $NNT_k$ je zbroj anuiteta i drugih uplata (pozitivni novčani tok) umanjen za zbroj isplata kredita i drugih isplata (negativni novčani tok) u $k$-tom razdoblju.

$$DNNT_k = NNT_k \cdot \left(1 + \frac{PGS}{100}\right)^{-\frac{d_k}{t}}$$

  $PGS$ – postotna godišnja stopa

# EKS kod kredita

- Izračunamo postotnu godišnju kamatnu stopu tako da sumu diskontiranih neto novčanih tokova izjednačimo s nulom i pronađemo rješenje pripadne jednadžbe.

$$\sum_k NNT_k \cdot \left(1 + \frac{PGS}{100}\right)^{-\frac{d_k}{t}} = 0$$

- Odredimo efektivnu kamatnu stopu prema formuli

$$EKS = PGS \cdot \frac{UDIK}{UDIK - UDTSP}.$$

# EKS kod kredita

- Diskontirane isplate kredita

$$DIK_k = IK_k \cdot \left(1 + \frac{PGS}{100}\right)^{-\frac{d_k}{t}}$$

$$UDIK = \sum_k DIK_k$$

- Diskontirani tokovi sigurnosnog pologa

$$DTSP_k = TSP_k \cdot \left(1 + \frac{PGS}{100}\right)^{-\frac{d_k}{t}}$$

$$UDTSP = \sum_k DTSP_k$$