UNIVERZA V LJUBLJANI | EF Ekonomska fakulteta

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# Izzivi poučevanja finančne matematike v angleščini

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Konferenca slovenskih matematikov 2025

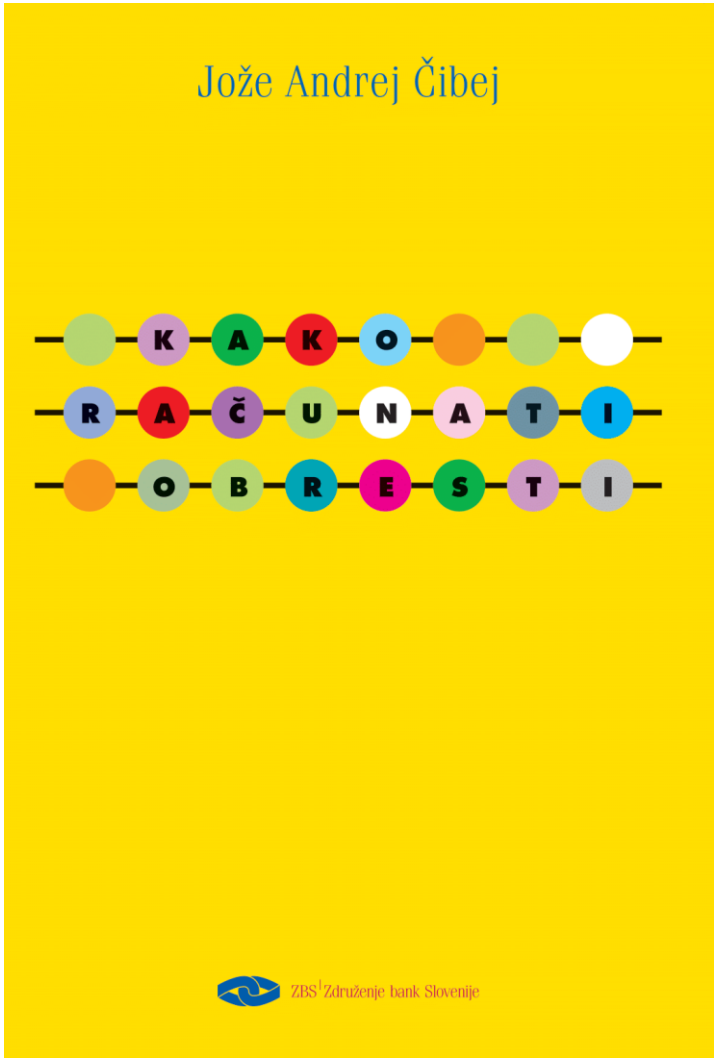
Koper, 12. september 2025

# Opredelitev FM: Učni načrt matematike v gimnazijah


Dijaki/dijakinje:

- razlikujejo **navadno** in **obrestno** obrestovanje,
- razlikujejo med **konformno** in **relativno** obrestno mero,
- uporabijo **načelo ekvivalence glavnic**,
- poiščejo realne primere obrestovanja, napovejo pričakovanja in se odločijo na osnovi simulativnih izračunov,
- izračunajo **anuiteto** in izdelajo **amortizacijski načrt**.

# Priporočila Banke Slovenije in drugi viri

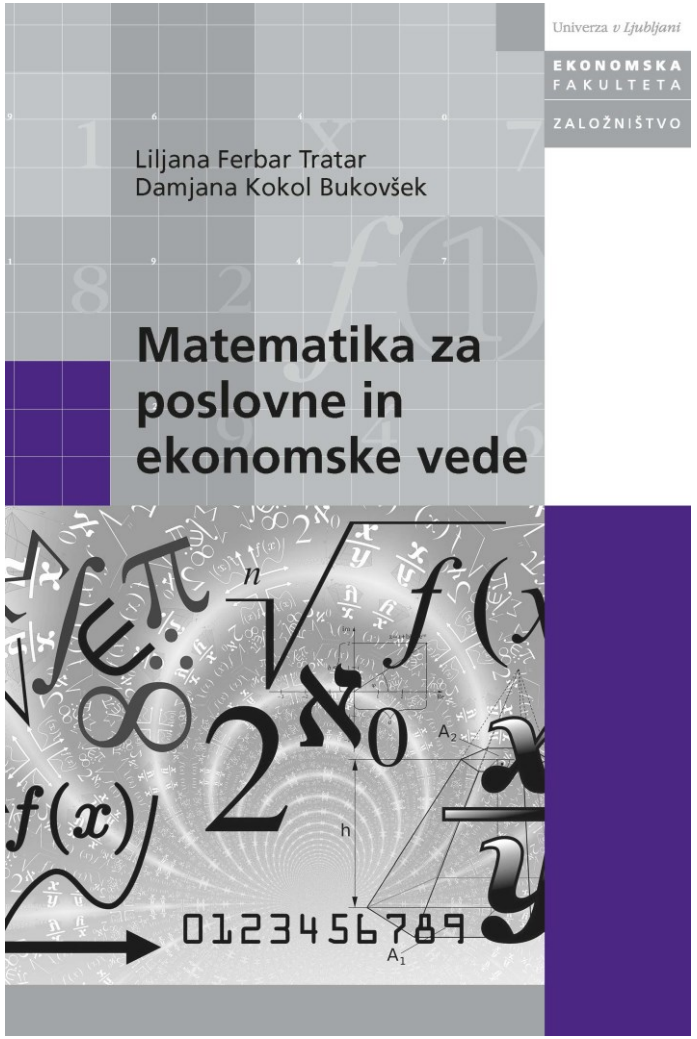


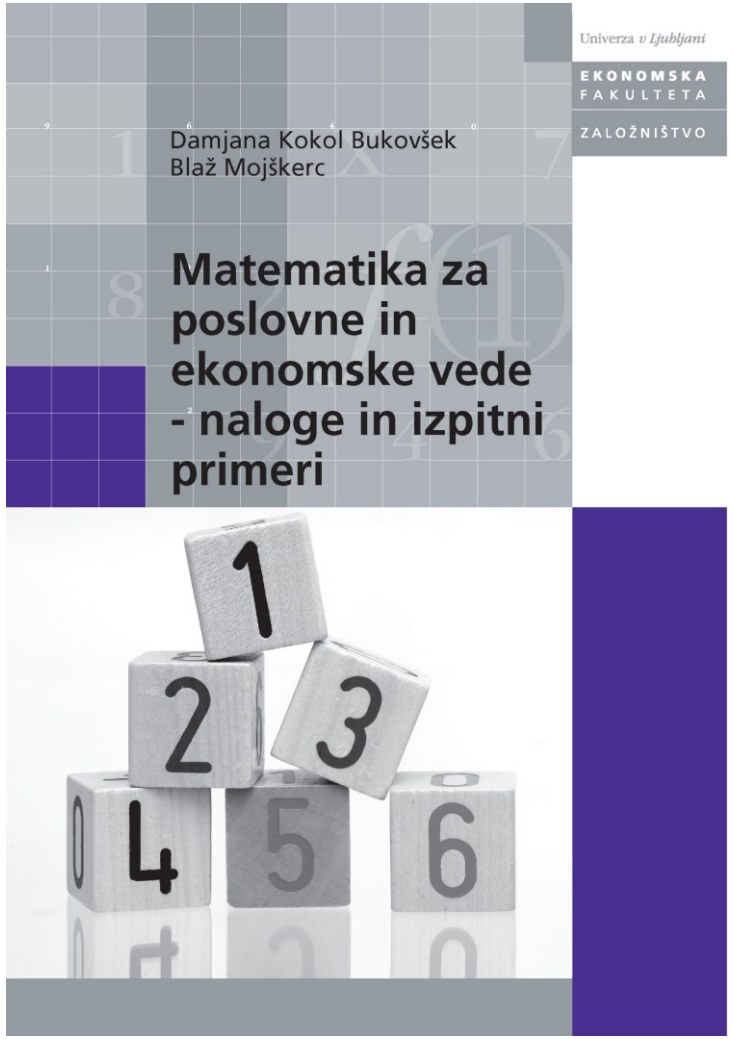

- Glavnici $G_Z$ in $G_K$
- Obrestna mera $p\ \%$
- Znesek obresti $o = \frac{G \cdot p \cdot m}{1200}$ ali $o = \frac{G \cdot p \cdot d}{36500}$
- Čas obrestovanja $t = \frac{m}{12}$ ali $t = \frac{d}{365}$
- Letni obrestni faktor $r = 1 + \frac{p}{100}$

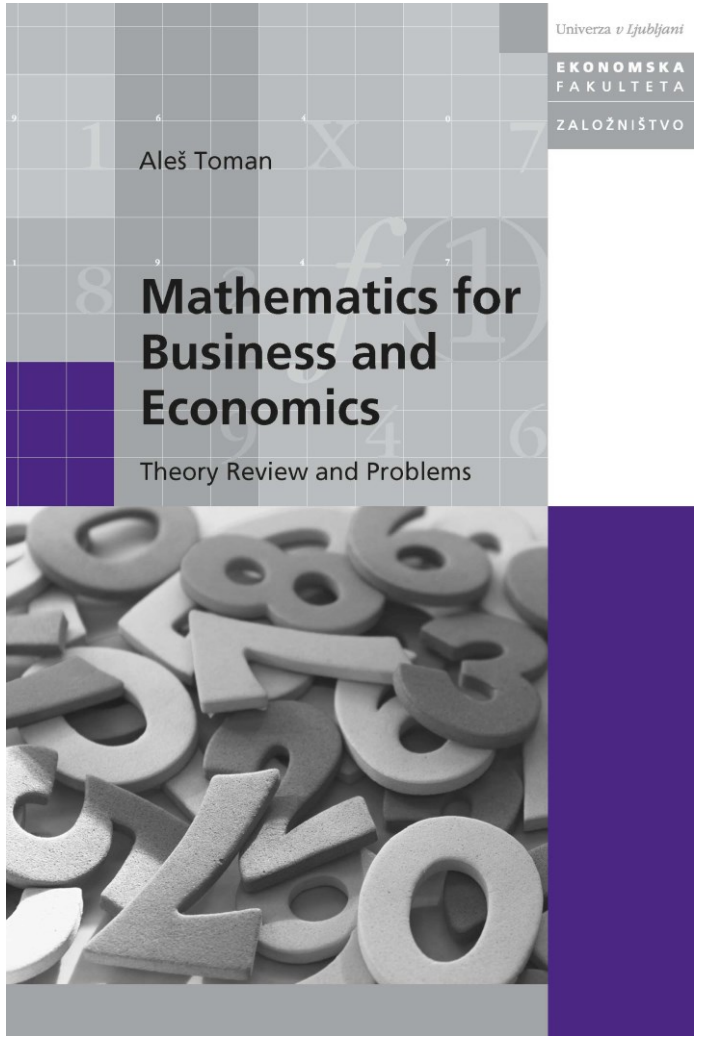
BANKA SLOVENIJE
EVROSISTEM

ZBS | Združenje bank Slovenije

# Učbeniki za matematiko (1. letnik) na Ekonomski fakulteti



# Delna rešitev (2019) *When in Rome …*

| Matematika | Mathematics |
|---|---|
| Glavnica $G$ | Balance $B$ |
| Obrestna mera $p$ % | Interest rate $R$ (e.g., $R = 5\% = 0.05$) |
| Obresti $o$ | Interest amount $I$ |
| **Navadno obrestovanje** | **Simple interest** ~~(Simple compounding)~~ |
| $o = \frac{G \cdot p \cdot m}{1200} = \frac{G \cdot p \cdot d}{36500}$ | $I = B \cdot R \cdot T$, where $T = \frac{m}{12} = \frac{d}{365}$ is time in years |
| Kredit, posojilo | (Instalment) loan |
| Anuiteta | Instalment amount ~~(Annuity)~~ |

# Delna rešitev (2019) *When in Rome …*

| Matematika | Mathematics |
|---|---|
| **Obrestno obrestovanje** | **Compound interest** (compounding) |
| Letni obrestni faktor $r = 1 + \frac{p}{100}$ | Yearly/Annual interest factor $k = 1 + R$ |
| **Relativna** obrestna mera | **Relative** interest rate |
| $r = 1 + \frac{p}{1200}$ ali $r = 1 + \frac{p}{36500}$ | $k = 1 + \frac{R}{12}$ or $k = 1 + \frac{R}{365}$ |
| **Konformna** obrestna mera | **Conform** interest rate |
| $r = \sqrt[12]{1 + \frac{p}{100}}$ ali $r = \sqrt[365]{1 + \frac{p}{100}}$ | $k = \sqrt[12]{1 + R}$ or $k = \sqrt[365]{1 + R}$ |

# Mednarodna ekonomska olimpijada (2022–)


INTERNATIONAL
ECONOMICS
OLYMPIAD

dMFA

A company takes, at the "zero" time instant, a loan equal to 71 money units and plans to pay the first month 15 money units, the second 28 and the third 30, that is $P_1 = 15$, $P_2 = 28$, $P_3 = 30$

(a) (10 rp) Using the above procedure calculate the IRR for this payment flow. Use $r_0 = 0.14$, applied annually, and increase it with step $h = 0.01$ up to the value $r = 0.16$.

(b) (10 rp) If the company, instead of following this payment policy, decides to give 25 money units on the third month and some amount of money the fifth month, what should this amount be, in order the whole loan to be repaid? As an annual interest rate, use the IRR we found before.

(c) (10 rp) The company has started to repay the loan by 5 equal monthly payments, covering both principal and interest and with an interest rate equal to the IRR, found before. Suddenly after the second payment, the interest rate is increased by 3%. The government, in order to help, decides to cover the 25% of the loan which has not been paid yet and to extend the number of total payments from 5 to 8. Find the amount of each equal monthly payment, the company must pay from now on, to repay the loan.

Relativna ali konformna obrestna mera?

**Solution**

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(a) (10 points) Relativna ali konformna obrestna mera?

For $r_0$=0,14 we have:

$$NPV(0{,}14) = P_0 \cdot (1 + \frac{0{,}14}{12})^0 + P_1 \cdot (1 + \frac{0{,}14}{12})^{-1} + P_2 \cdot (1 + \frac{0{,}14}{12})^{-2} + P_3 \cdot (1 + \frac{0{,}14}{12})^{-3}$$
$$= 0{,}158975$$

For $r_0$=0,15 we have:

$$NPV(0{,}15) = P_0 \cdot (1 + \frac{0{,}15}{12})^0 + P_1 \cdot (1 + \frac{0{,}15}{12})^{-1} + P_2 \cdot (1 + \frac{0{,}15}{12})^{-2} + P_3 \cdot (1 + \frac{0{,}15}{12})^{-3}$$
$$= 0{,}0302743$$

For $r_0$=0,16 we have:

$$NPV(0{,}16) = P_0 \cdot (1 + \frac{0{,}16}{12})^0 + P_1 \cdot (1 + \frac{0{,}16}{12})^{-1} + P_2 \cdot (1 + \frac{0{,}16}{12})^{-2} + P_3 \cdot (1 + \frac{0{,}16}{12})^{-3}$$
$$= -0{,}09806$$

# Annual Percentage Rate | Annual Percentage Yield | Annual Effective Rate

## APR

vs.

## APY

Generally measures
**interest charged when you borrow money**

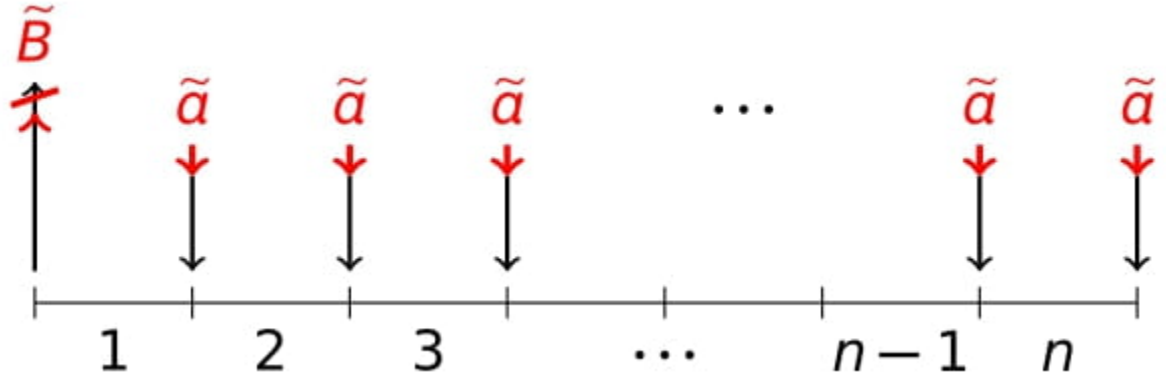
Usually associated with
**credit accounts**

Generally measures
**interest earned when you save or invest money**

Usually associated with
**deposit accounts**

# Annual Percentage Rate (APR)

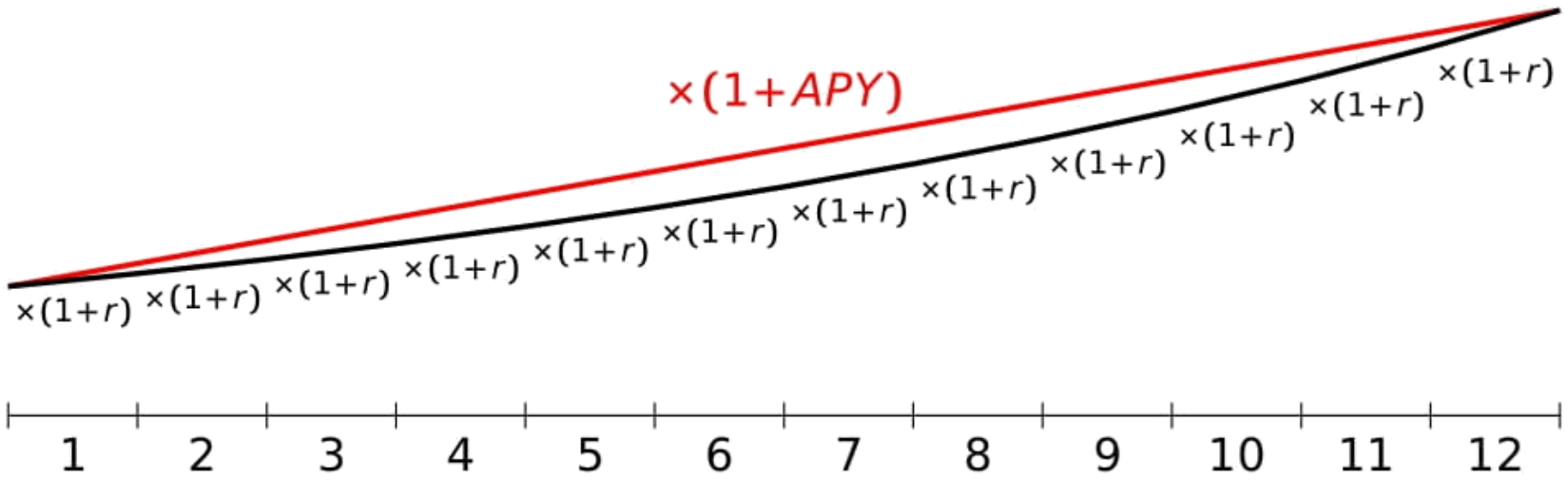
- Upošteva vse s kreditom povezane denarne tokove $(B, R_n \implies a)$
  (od glavnice odštej stroške odobritve, anuitetam prištej stroške vodenja kredita)
  (v šolskih nalogah te podrobnosti izpustimo)




- Mesečna obrestna mera $r$ $(\tilde{B}, \tilde{a} \implies r)$
- Letna obrestna mera $\boxed{APR = 12r \implies r = \frac{APR}{12}}$
- Uporabljamo **relativni način obrestovanja**

# Annual Percentage Yield (APY)

- Ne upošteva stroškov
- Upošteva učinek obrestnega obrestovanja




- Mesečna obrestna mera $r$
- Letna obrestna mera $\boxed{1 + APY = (1 + r)^{12} \implies r = \sqrt[12]{1 + APY} - 1}$
- Uporabljamo **konformni način obrestovanja**

**(a)** (5 pt) Congratulations! You are admitted to Harvard and approved for a student loan to finance tuition ($60,000 per year), room and board ($20,000 per year), and other expenses ($7,000 per year) for four years. The loan has an annual interest rate of 8% and must be repaid in equal annual payments over 30 years after graduation (assume there is no interest while you are in college, the first payment happens in 5 years from now).

Explain why your annual payments are $30,912.

**(e)** (10 pt) To pay for the education, the government decided to increase income tax to 50% for the high-income earners (starting at $100k a year). Unfortunately, higher taxes have reduced the expected economic growth from 3% to 1% a year. Assume that a typical working span is 45 years and calculate the value of after-tax salaries under the educational loans (starting salary $100k, grows at 3% for 45 years, tax 25%, minus the loan repayments) and then compare it with the government-funded education (starting salary $100k, grows at 1% for 45 years, tax 50%, no loan repayments). Discount at 8%. Explain which one is better for you.

## (a) The Individual Burden (5 points)

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### Calculation Annual Payment:

Loan Amount = ($60,000 + $20,000 + $7,000) * 4 = $348,000

Plugging these into the annuity formula: 0.08 * $348,000 / (1 - 1/1.08^30) = $**30,912**

## (e) Paying for the government-funded education (10 points)

Scenario 1: Education Loans

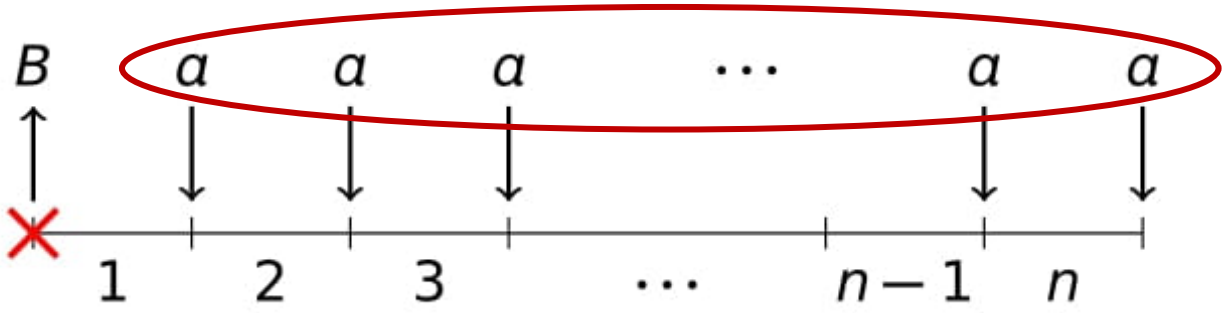
Using the growing annuity formula, the present value of the after-tax salary payments in the first scenario:

1) $PV(after - tax\ salary) = \frac{\$100{,}000*(1-0.25)}{0.08-0.03}\left(1 - \frac{(1+0.03)^{45}}{(1+0.08)^{45}}\right)$=$1,322,300

Since the discount rate is the same as the interest rate on the loan, the present value of the loan payments is equal to the value of the loan. Hence, the net value of this option to you is $1,322,300 - $348,000=$974,300.

# Annuity Formula

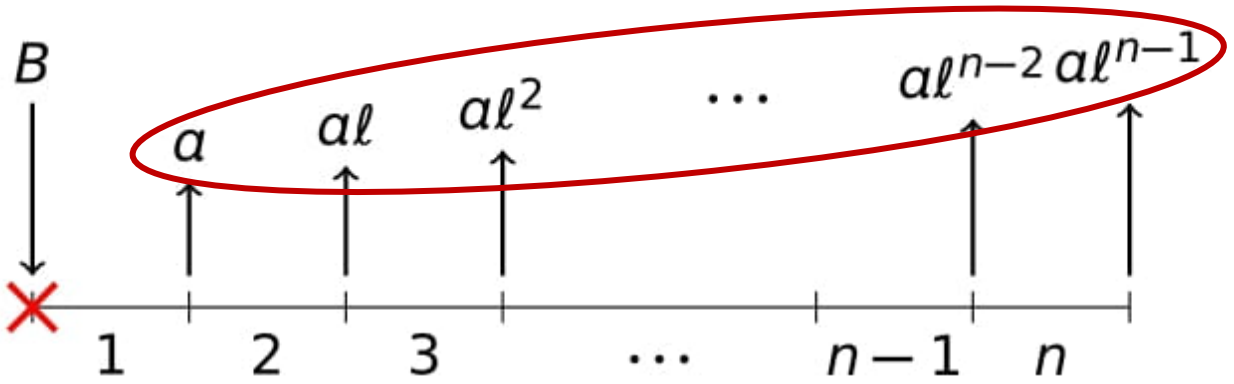
- Sedanja vrednost postnumerandne rente
- Višina anuitete kredita z glavnico $B$
- Obdobni obrestni faktor $k = 1 + r$




- $B = \frac{a}{k} + \frac{a}{k^2} + \cdots + \frac{a}{k^n} = \frac{a}{k^n}(k^{n-1} + k^{n-2} + \cdots + 1) = \frac{a}{k^n} \cdot \frac{k^n - 1}{k-1} = \boxed{\frac{a}{(1+r)^n} \cdot \frac{(1+r)^n - 1}{r}}$
- $a = Bk^n \cdot \frac{k-1}{k^n - 1} = \boxed{Br \cdot \frac{(1+r)^n}{(1+r)^n - 1}} = \boxed{Br \cdot \frac{1}{1 - \frac{1}{(1+r)^n}}}$

# Growing Annuity Formula

- Sedanja vrednost naraščajoče postnumerandne rente
- Obdobni obrestni faktor $k = 1 + r$
- Obdobni faktor rasti $\ell = 1 + g$

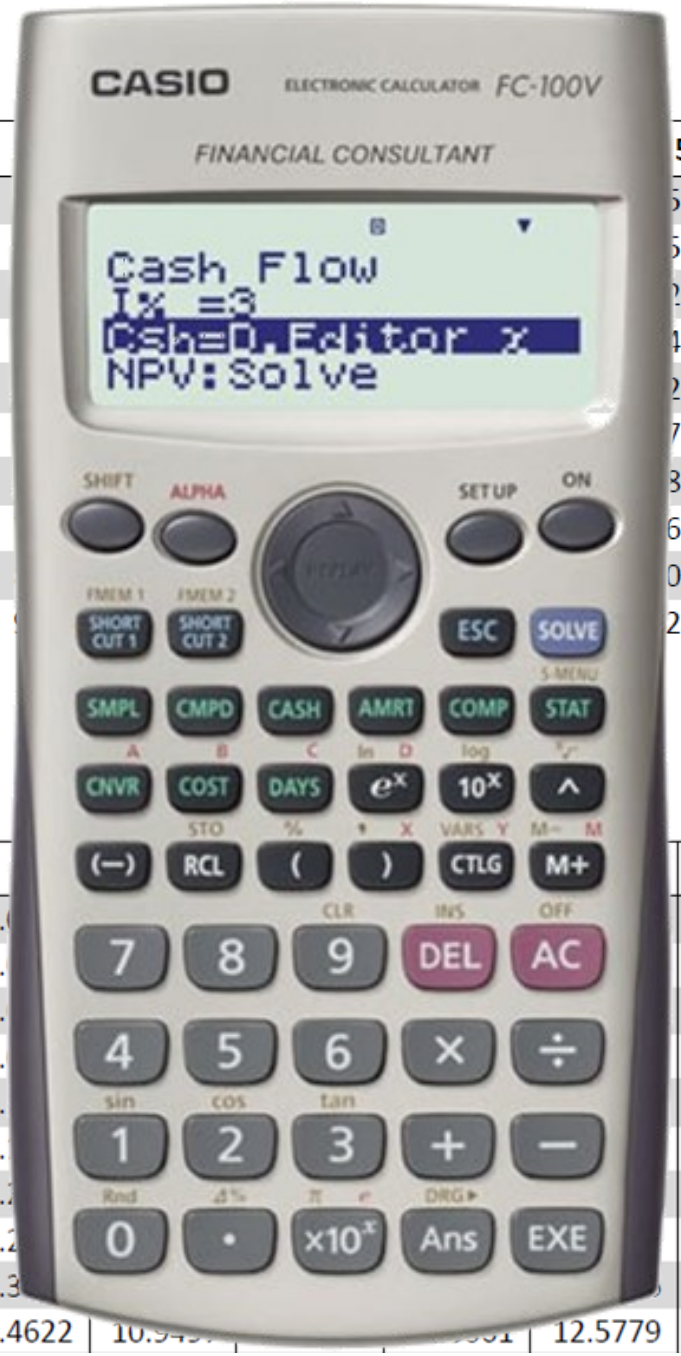



- $B = \frac{a}{k} + \frac{a\ell}{k^2} + \cdots + \frac{a\ell^{n-1}}{k^n} = \frac{a}{k}\left(1 + \frac{\ell}{k} + \cdots + \frac{\ell^{n-1}}{k^{n-1}}\right) = \frac{a}{k} \cdot \frac{\left(\frac{\ell}{k}\right)^n - 1}{\frac{\ell}{k} - 1}$
- $B = \frac{a}{\ell - k} \cdot \frac{\ell^n - k^n}{k^n} = \frac{a}{r - g} \cdot \frac{(1+r)^n - (1+g)^n}{(1+r)^n} = \boxed{\frac{a}{r-g} \cdot \left(1 - \frac{(1+g)^n}{(1+r)^n}\right)}$

**Question 25. Investment, Financial Instruments, and Risk Management**

Rick is a young devoted father and wants to save up to finance his daughter Collete's college expenses. The cost of four years of college right now is $250,000 and it is projected to grow at 12% a year. Colette is currently 3 years old so Rick has 15 years of investment. He is considering the following options: high-yield savings account that delivers 5% a year or investing in a mutual fund that replicates S&P 500 returns with annual return on average of 10% a year. What is the annual investment that Rick needs to do under each one of the investment plans: (annuity factor for 15 years at 5% is 21.58, at 10% is 31.77)

A. Savings: $63,410, Investment: $43,071
B. Savings: $53,410, Investment: $53,410
C. Savings: $60,000, Investment: $30,000
D. Savings: $61,315, Investment: $40,851




## Present Value Annuity Tables

Formula: $PV = [1- 1 / (1 + i)^n] / i$

| n / i | | | | | 5% | 6% | 7% | 8% | 9% | 10% | 11% | 12% | 13% | 14% | 15% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | 524 | 0.9434 | 0.9346 | 0.9259 | 0.9174 | 0.9091 | 0.9009 | 0.8929 | 0.8850 | 0.8772 | 0.8696 |
| 2 | | | | | 594 | 1.8334 | 1.8080 | 1.7833 | 1.7591 | 1.7355 | 1.7125 | 1.6901 | 1.6681 | 1.6467 | 1.6257 |
| 3 | | | | | 232 | 2.6730 | 2.6243 | 2.5771 | 2.5313 | 2.4869 | 2.4437 | 2.4018 | 2.3612 | 2.3216 | 2.2832 |
| 4 | | | | | 460 | 3.4651 | 3.3872 | 3.3121 | 3.2397 | 3.1699 | 3.1024 | 3.0373 | 2.9745 | 2.9137 | 2.8550 |
| 5 | | | | | 295 | 4.2124 | 4.1002 | 3.9927 | 3.8897 | 3.7908 | 3.6959 | 3.6048 | 3.5172 | 3.4331 | 3.3522 |
| 6 | | | | | 757 | 4.9173 | 4.7665 | 4.6229 | 4.4859 | 4.3553 | 4.2305 | 4.1114 | 3.9975 | 3.8887 | 3.7845 |
| 7 | | | | | 364 | 5.5824 | 5.3893 | 5.2064 | 5.0330 | 4.8684 | 4.7122 | 4.5638 | 4.4226 | 4.2883 | 4.1604 |
| 8 | | | | | 632 | 6.2098 | 5.9713 | 5.7466 | 5.5348 | 5.3349 | 5.1461 | 4.9676 | 4.7988 | 4.6389 | 4.4873 |
| 9 | | | | | 078 | 6.8017 | 6.5152 | 6.2469 | 5.9952 | 5.7590 | 5.5370 | 5.3282 | 5.1317 | 4.9464 | 4.7716 |
| 10 | | | | | 217 | 7.3601 | 7.0236 | 6.7101 | 6.4177 | 6.1446 | 5.8892 | 5.6502 | 5.4262 | 5.2161 | 5.0188 |

## Future Value Annuity Tables

Formula: $FV = [(1 + i)^n - 1] / i$

| n / i | | | | | 6% | 7% | 8% | 9% | 10% | 11% | 12% | 13% | 14% | 15% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1. | | | | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 2 | 2. | | | | 2.0600 | 2.0700 | 2.0800 | 2.0900 | 2.1000 | 2.1100 | 2.1200 | 2.1300 | 2.1400 | 2.1500 |
| 3 | 3. | | | | 3.1836 | 3.2149 | 3.2464 | 3.2781 | 3.3100 | 3.3421 | 3.3744 | 3.4069 | 3.4396 | 3.4725 |
| 4 | 4. | | | | 4.3746 | 4.4399 | 4.5061 | 4.5731 | 4.6410 | 4.7097 | 4.7793 | 4.8498 | 4.9211 | 4.9934 |
| 5 | 5. | | | | 5.6371 | 5.7507 | 5.8666 | 5.9847 | 6.1051 | 6.2278 | 6.3528 | 6.4803 | 6.6101 | 6.7424 |
| 6 | 6. | | | | 6.9753 | 7.1533 | 7.3359 | 7.5233 | 7.7156 | 7.9129 | 8.1152 | 8.3227 | 8.5355 | 8.7537 |
| 7 | 7. | | | | 8.3938 | 8.6540 | 8.9228 | 9.2004 | 9.4872 | 9.7833 | 10.0890 | 10.4047 | 10.7305 | 11.0668 |
| 8 | 8. | | | | 9.8975 | 10.2598 | 10.6366 | 11.0285 | 11.4359 | 11.8594 | 12.2997 | 12.7573 | 13.2328 | 13.7268 |
| 9 | 9. | | | | 11.4913 | 11.9780 | 12.4876 | 13.0210 | 13.5795 | 14.1640 | 14.7757 | 15.4157 | 16.0853 | 16.7858 |
| 10 | 10.4622 | | | 12.5779 | 13.1808 | 13.8164 | 14.4866 | 15.1929 | 15.9374 | 16.7220 | 17.5487 | 18.4197 | 19.3373 | 20.3037 |

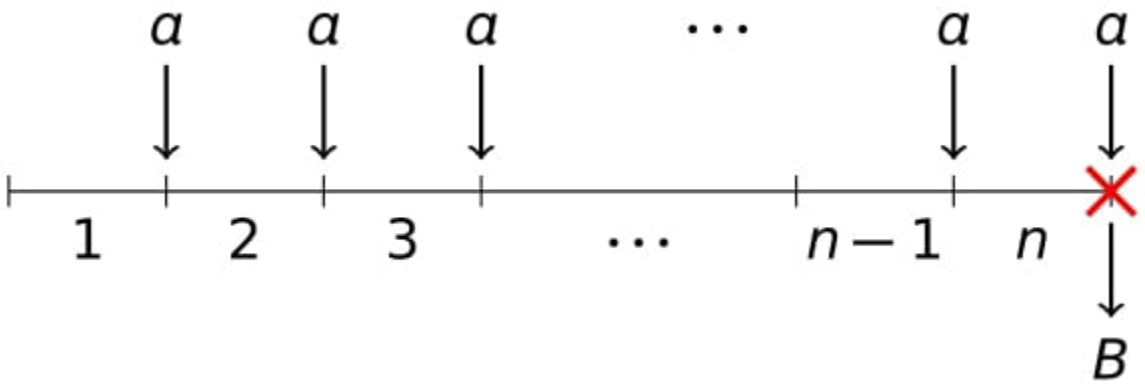
# Future Value Annuity Tables

Formula: $FV = [(1 + i)^n - 1] / i$

| n / i | 1% | 2% | 3% | 4% | 5% | 6% | 7% | 8% | 9% | 10% | 11% | 12% | 13% | 14% | 15% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 2 | 2.0100 | 2.0200 | 2.0300 | 2.0400 | 2.0500 | 2.0600 | 2.0700 | 2.0800 | 2.0900 | 2.1000 | 2.1100 | 2.1200 | 2.1300 | 2.1400 | 2.1500 |
| 3 | 3.0301 | 3.0604 | 3.0909 | 3.1216 | 3.1525 | 3.1836 | 3.2149 | 3.2464 | 3.2781 | 3.3100 | 3.3421 | 3.3744 | 3.4069 | 3.4396 | 3.4725 |
| 4 | 4.0604 | 4.1216 | 4.1836 | 4.2465 | 4.3101 | 4.3746 | 4.4399 | 4.5061 | 4.5731 | 4.6410 | 4.7097 | 4.7793 | 4.8498 | 4.9211 | 4.9934 |
| 5 | 5.1010 | 5.2040 | 5.3091 | 5.4163 | 5.5256 | 5.6371 | 5.7507 | 5.8666 | 5.9847 | 6.1051 | 6.2278 | 6.3528 | 6.4803 | 6.6101 | 6.7424 |
| 6 | 6.1520 | 6.3081 | 6.4684 | 6.6330 | 6.8019 | 6.9753 | 7.1533 | 7.3359 | 7.5233 | 7.7156 | 7.9129 | 8.1152 | 8.3227 | 8.5355 | 8.7537 |
| 7 | 7.2135 | 7.4343 | 7.6625 | 7.8983 | 8.1420 | 8.3938 | 8.6540 | 8.9228 | 9.2004 | 9.4872 | 9.7833 | 10.0890 | 10.4047 | 10.7305 | 11.0668 |
| 8 | 8.2857 | 8.5830 | 8.8923 | 9.2142 | 9.5491 | 9.8975 | 10.2598 | 10.6366 | 11.0285 | 11.4359 | 11.8594 | 12.2997 | 12.7573 | 13.2328 | 13.7268 |
| 9 | 9.3685 | 9.7546 | 10.1591 | 10.5828 | 11.0266 | 11.4913 | 11.9780 | 12.4876 | 13.0210 | 13.5795 | 14.1640 | 14.7757 | 15.4157 | 16.0853 | 16.7858 |
| 10 | 10.4622 | 10.9497 | 11.4639 | 12.0061 | 12.5779 | 13.1808 | 13.8164 | 14.4866 | 15.1929 | 15.9374 | 16.7220 | 17.5487 | 18.4197 | 19.3373 | 20.3037 |
| 11 | 11.5668 | 12.1687 | 12.8078 | 13.4864 | 14.2068 | 14.9716 | 15.7836 | 16.6455 | 17.5603 | 18.5312 | 19.5614 | 20.6546 | 21.8143 | 23.0445 | 24.3493 |
| 12 | 12.6825 | 13.4121 | 14.1920 | 15.0258 | 15.9171 | 16.8699 | 17.8885 | 18.9771 | 20.1407 | 21.3843 | 22.7132 | 24.1331 | 25.6502 | 27.2707 | 29.0017 |
| 13 | 13.8093 | 14.6803 | 15.6178 | 16.6268 | 17.7130 | 18.8821 | 20.1406 | 21.4953 | 22.9534 | 24.5227 | 26.2116 | 28.0291 | 29.9847 | 32.0887 | 34.3519 |
| 14 | 14.9474 | 15.9739 | 17.0863 | 18.2919 | 19.5986 | 21.0151 | 22.5505 | 24.2149 | 26.0192 | 27.9750 | 30.0949 | 32.3926 | 34.8827 | 37.5811 | 40.5047 |
| 15 | 16.0969 | 17.2934 | 18.5989 | 20.0236 | 21.5786 | 23.2760 | 25.1290 | 27.1521 | 29.3609 | 31.7725 | 34.4054 | 37.2797 | 40.4175 | 43.8424 | 47.5804 |
| 16 | 17.2579 | 18.6393 | 20.1569 | 21.8245 | 23.6575 | 25.6725 | 27.8881 | 30.3243 | 33.0034 | 35.9497 | 39.1899 | 42.7533 | 46.6717 | 50.9804 | 55.7175 |
| 17 | 18.4304 | 20.0121 | 21.7616 | 23.6975 | 25.8404 | 28.2129 | 30.8402 | 33.7502 | 36.9737 | 40.5447 | 44.5008 | 48.8837 | 53.7391 | 59.1176 | 65.0751 |
| 18 | 19.6147 | 21.4123 | 23.4144 | 25.6454 | 28.1324 | 30.9057 | 33.9990 | 37.4502 | 41.3013 | 45.5992 | 50.3959 | 55.7497 | 61.7251 | 68.3941 | 75.8364 |
| 19 | 20.8109 | 22.8406 | 25.1169 | 27.6712 | 30.5390 | 33.7600 | 37.3790 | 41.4463 | 46.0185 | 51.1591 | 56.9395 | 63.4397 | 70.7494 | 78.9692 | 88.2118 |
| 20 | 22.0190 | 24.2974 | 26.8704 | 29.7781 | 33.0660 | 36.7856 | 40.9955 | 45.7620 | 51.1601 | 57.2750 | 64.2028 | 72.0524 | 80.9468 | 91.0249 | 102.4436 |
| 21 | 23.2392 | 25.7833 | 28.6765 | 31.9692 | 35.7193 | 39.9927 | 44.8652 | 50.4229 | 56.7645 | 64.0025 | 72.2651 | 81.6987 | 92.4699 | 104.7684 | 118.8101 |
| 22 | 24.4716 | 27.2990 | 30.5368 | 34.2480 | 38.5052 | 43.3923 | 49.0057 | 55.4568 | 62.8733 | 71.4027 | 81.2143 | 92.5026 | 105.4910 | 120.4360 | 137.6316 |
| 23 | 25.7163 | 28.8450 | 32.4529 | 36.6179 | 41.4305 | 46.9958 | 53.4361 | 60.8933 | 69.5319 | 79.5430 | 91.1479 | 104.6029 | 120.2048 | 138.2970 | 159.2764 |
| 24 | 26.9735 | 30.4219 | 34.4265 | 39.0826 | 44.5020 | 50.8156 | 58.1767 | 66.7648 | 76.7898 | 88.4973 | 102.1742 | 118.1552 | 136.8315 | 158.6586 | 184.1678 |
| 25 | 28.2432 | 32.0303 | 36.4593 | 41.6459 | 47.7271 | 54.8645 | 63.2490 | 73.1059 | 84.7009 | 98.3471 | 114.4133 | 133.3339 | 155.6196 | 181.8708 | 212.7930 |

# Future Value Annuity Factor

- Prihodnja vrednost postnumerandne rente
- Obdobni obrestni faktor $k = 1 + r$




- $B = ak^{n-1} + ak^{n-2} + \cdots + a = a(k^{n-1} + k^{n-2} + \cdots + 1) = a \cdot \frac{k^n - 1}{k-1} = a \cdot \frac{(1+r)^n - 1}{r}$
- $\boxed{FVAF = \frac{(1+r)^n - 1}{r}}$
- $r = 5\%$ in $n = 15 \implies FVAF = \frac{1{,}05^{15} - 1}{0{,}05} = 21{,}5786$

# Zaključek

- Izrazi in oznake v finančni matematiki so rezultat tradicije, zakonodaje in priporočil, ki veljajo v posamezni državi.
- Z vidika finančne pismenosti je koristno poznati izraze in oznake, ki so pogosti v mednarodnem okolju (v angleščini so referenca ZDA).
- Pomen medpredmetnega povezovanja na Ekonomski fakulteti (Berk, J. B., & DeMarzo, P. M. (2014). *Corporate Finance*. Pearson Education)
- Kar nekaj dodatnih vsebin, ki jih bomo morali vključiti v priprave na Mednarodno ekonomsko olimpijado

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# Hvala za pozornost

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