

# SL 1.4, SL 1.7 Finances 2

# Introduction

In this presentation we will review financial maths problems that involve loans and annuities.

# Example 1

Tomasz invests 100 000 PLN into savings account that pays 3% annual interest compounded monthly. At the end of each month he withdraws 1500 PLN from his account. Calculate how much money does he have on his account after 4 years.

Here we will go directly to TVM.

# Example 1

Tomasz invests 100 000 PLN into savings account that pays 3% annual interest compounded monthly. At the end of each month he withdraws 1500 PLN from his account. Calculate how much money does he have on his account after 4 years.

Here we will go directly to TVM.

# Example 1

We have:

$n = 48$  (we have 48 months in 4 years)

$i = 3\%$  (annual interest rate)

$PV = -100\,000$  (must be negative)

$PMT = 1500$  (must be positive, he gets this money)

$FV = ?$  (unknown)

$P/Y = 12$  (12 payments per year)

$C/Y = 12$  (compounded 12 times per year)

And we get  $FV = 36335.99$ .

# Example 1

We have:

$$n = 48 \text{ (we have 48 months in 4 years)}$$

$$I\% = 3 \text{ (annual interest rate)}$$

$$PV = -100\,000 \text{ (must be negative)}$$

$$PMT = 1500 \text{ (must be positive, he gets this money)}$$

$$FV = ? \text{ (unknown)}$$

$$P/Y = 12 \text{ (12 payments per year)}$$

$$C/Y = 12 \text{ (compounded 12 times per year)}$$

And we get  $FV = 36335.99$

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$$FV = ? \text{ (unknown)}$$

$$P/Y = 12 \text{ (12 payments per year)}$$

$$C/Y = 12 \text{ (compounded 12 times per year)}$$

And we get  $FV = 36335.99$ .

## Example 2

Tomasz invests 50 000 PLN into savings account that pays 2.2% annual interest compounded quarterly. At the end of each quarter he puts another 5000 PLN into his account. Calculate how much money does he have on his account after 5 years.

We will use TVM. Note that this time PMT will be negative, since he puts the money into the account.



## Example 2

Tomasz invests 50 000 PLN into savings account that pays 2.2% annual interest compounded quarterly. At the end of each quarter he puts another 5000 PLN into his account. Calculate how much money does he have on his account after 5 years.

We will use TVM. Note that this time PMT will be negative, since he puts the money into the account.

## Example 2

We should input:

$n = 20$  (we have 20 quarters in 5 years)

$i\% = 2.2$  (annual interest rate)

$PV = -50\,000$  (must be negative)

$PMT = -5000$  (negative, he invests the money)

$FV = ?$  (unknown)

$P/Y = 4$  (4 payments per year)

$C/Y = 4$  (compounded 4 times per year)

We get  $FV = 161198.61$ .

## Example 2

We should input:

$$n = 20 \text{ (we have 20 quarters in 5 years)}$$

$$I\% = 2.2 \text{ (annual interest rate)}$$

$$PV = -50\,000 \text{ (must be negative)}$$

$$PMT = -5000 \text{ (negative, he invests the money)}$$

$$FV = ? \text{ (unknown)}$$

$$P/Y = 4 \text{ (4 payments per year)}$$

$$C/Y = 4 \text{ (compounded 4 times per year)}$$

We get  $FV = 151198.61$ .

## Example 2

We should input:

$$n = 20 \text{ (we have 20 quarters in 5 years)}$$

$$I\% = 2.2 \text{ (annual interest rate)}$$

$$PV = -50\,000 \text{ (must be negative)}$$

$$PMT = -5000 \text{ (negative, he invests the money)}$$

$$FV = ? \text{ (unknown)}$$

$$P/Y = 4 \text{ (4 payments per year)}$$

$$C/Y = 4 \text{ (compounded 4 times per year)}$$

We get  $FV = 161198.61$ .

## Example 3

Tomasz takes a loan of 120 000 PLN. The loan is to be repaid in 20 years with equal monthly payments. The annual interest on the loan is 4.5% compounded monthly. Calculate the monthly repayments.

Again we will use TVM.

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Again we will use TVM.

## Example 3

We have:

$n = 240$  (we have 240 months in 20 years)

$i\% = 4.5$  (annual interest rate)

$PV = 120\,000$  (this time it's positive as we get this money)

$PMT = ?$  (we want to calculate the repayments, they will be negative)

$FV = 0$  (the loan needs to be repaid)

$P/Y = 12$  (12 payments per year)

$C/Y = 12$  (compounded 12 times per year)

And we get  $PMT = -759.18$ . So Tomasz needs to pay 759.18 PLN per month to repay his loan in 20 years.

## Example 3

We have:

$$n = 240 \text{ (we have 240 months in 20 years)}$$

$$I\% = 4.5 \text{ (annual interest rate)}$$

$$PV = 120\,000 \text{ (this time it's positive as we get this money)}$$

$$PMT = ? \text{ (we want to calculate the repayments, they will be negative)}$$

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$$P/Y = 12 \text{ (12 payments per year)}$$

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And we get  $PMT = -759.18$ . So Tomasz needs to pay 759.18 PLN per month to repay his loan in 20 years.



## Example 3

We have:

$$n = 240 \text{ (we have 240 months in 20 years)}$$

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$$PV = 120\,000 \text{ (this time it's positive as we get this money)}$$

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$$FV = 0 \text{ (the loan needs to be repaid)}$$

$$P/Y = 12 \text{ (12 payments per year)}$$

$$C/Y = 12 \text{ (compounded 12 times per year)}$$

And we get  $PMT = -759.18$ . So Tomasz needs to pay 759.18 PLN per month to repay his loan in 20 years.

## Example 4

Tomasz invests 150 000 PLN into an annuity that pays a fixed amount of money per month. The annual interest on the annuity is 1.5% and it is compounded monthly. Calculate how much money can Tomasz receive each month, if the annuity is to last for 15 year.

TVM on the next slide.

## Example 4

Our inputs:

$n = 180$  (we have 180 months in 15 years)

$i\% = 1.5$  (annual interest rate)

$PV = -150\,000$  (negative, he invests it)

$PMT = ?$  (should be positive, as he gets this money)

$FV = 0$  (no more money on the investment)

$P/Y = 12$  (12 payments per year)

$C/Y = 12$  (compounded 12 times per year)

And we get  $PMT = 931.11$ . Tomasz can withdraw 931.11 PLN each month for 15 years.

## Example 4

Our inputs:

$n = 180$  (we have 180 months in 15 years)

$i\% = 1.5$  (annual interest rate)

$PV = -150\,000$  (negative, he invests it)

$PMT = ?$  (should be positive, as he gets this money)

$FV = 0$  (no more money on the investment)

$P/Y = 12$  (12 payments per year)

$C/Y = 12$  (compounded 12 times per year)

And we get  $PMT = 931.11$ . Tomasz can withdraw 931.11 PLN each month for 15 years.

## Example 4

Our inputs:

$n = 180$  (we have 180 months in 15 years)

$i\% = 1.5$  (annual interest rate)

$PV = -150\,000$  (negative, he invests it)

$PMT = ?$  (should be positive, as he gets this money)

$FV = 0$  (no more money on the investment)

$P/Y = 12$  (12 payments per year)

$C/Y = 12$  (compounded 12 times per year)

And we get  $PMT = 931.11$ . Tomasz can withdraw 931.11 PLN each month for 15 years.

Now we move on to some more complicated examples. These are the types of examples you may expect to appear on the exam.

Quick note on writing out the solution. If you use TVM on GDC, then as your solution you should write down your GDC input ( $n=...$ ,  $i\% = ...$ , etc.). But make sure you write down the answer explicitly, for example: "Tomasz needs to invest 666 PLN".

Now we move on to some more complicated examples. These are the types of examples you may expect to appear on the exam.

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Now we move on to some more complicated examples. These are the types of examples you may expect to appear on the exam.

Quick note on writing out the solution. If you use TVM on GDC, then as your solution you should write down your GDC input ( $n=...$ ,  $i\% = ...$ , etc.). But make sure you write down the answer explicitly, for example: "Tomasz needs to invest 666 PLN".



# Exam-style question 1

Maria takes a loan of 300 000 PLN. The annual interest on the loan is 3.5% and it is compounded monthly.

- (a) Calculate the monthly repayments if the loan is to be repaid in 20 years.
- (b) Calculate the total interest Maria would pay for her loan.
- (c) After 10 years Maria is able to increase the monthly repayments to 2500 PLN. Calculate how long it will take to repay the whole loan.

# Exam-style question 1a

Part (a) is easy:

$n = 240$  (we have 240 months in 20 years)

$i\% = 3.5$  (annual interest rate)

$PV = 300\,000$  (positive, she gets this money)

$PMT = ?$  (should be negative as she repays it)

$FV = 0$  (loan is repaid)

$P/Y = 12$  (12 payments per year)

$C/Y = 12$  (compounded 12 times per year)

And we get  $PMT = -1739.88$ . Maria needs to pay 1739.88 PLN each month to repay her loan in 20 years.

## Exam-style question 1a

Part (a) is easy:

$n = 240$  (we have 240 months in 20 years)

$i\% = 3.5$  (annual interest rate)

$PV = 300\,000$  (positive, she gets this money)

$PMT = ?$  (should be negative as she repays it)

$FV = 0$  (loan is repaid)

$P/Y = 12$  (12 payments per year)

$C/Y = 12$  (compounded 12 times per year)

And we get  $PMT = -1739.88$ . Maria needs to pay 1739.88 PLN each month to repay her loan in 20 years.

## Exam-style question 1a

Part (a) is easy:

$n = 240$  (we have 240 months in 20 years)

$i\% = 3.5$  (annual interest rate)

$PV = 300\,000$  (positive, she gets this money)

$PMT = ?$  (should be negative as she repays it)

$FV = 0$  (loan is repaid)

$P/Y = 12$  (12 payments per year)

$C/Y = 12$  (compounded 12 times per year)

And we get  $PMT = -1739.88$ . Maria needs to pay 1739.88 PLN each month to repay her loan in 20 years.

## Exam-style question 1b

In part (b) we first need to calculate how much she paid back. She paid 1739.88 per month for 240 months. So she paid a total of

$$1739.88 \cdot 240 = 417571.2$$

The loan was 300 000, so the total interest was:

$$417571.2 - 300000 = 117571.2$$

## Exam-style question 1b

In part (b) we first need to calculate how much she paid back. She paid 1739.88 per month for 240 months. So she paid a total of

$$1739.88 \cdot 240 = 417571.2$$

The loan was 300 000, so the total interest was:

$$417571.2 - 300000 = 117571.2$$

## Exam-style question 1c

Part (c) is done in 2 parts. First we need to see how much she still owes after 10 years:

$n = 120$  (we have 120 months in 10 years)

$i\% = 3.5$  (annual interest rate)

$FV = 300\,000$  (positive, she gets this money)

$PMT = -1739.88$  (should be negative as she repays it)

$FV = ?$  (how much she still owes)

$P/Y = 12$  (12 payments per year)

$C/Y = 12$  (compounded 12 times per year)

And we get  $FV = -175948.09$ . So she still need to repay 175948.09 PLN.

## Exam-style question 1c

Part (c) is done in 2 parts. First we need to see how much she still owes after 10 years:

$$n = 120 \text{ (we have 120 months in 10 years)}$$

$$i\% = 3.5 \text{ (annual interest rate)}$$

$$PV = 300\,000 \text{ (positive, she gets this money)}$$

$$PMT = -1739.88 \text{ (should be negative as she repays it)}$$

$$FV = ? \text{ (how much she still owes)}$$

$$P/Y = 12 \text{ (12 payments per year)}$$

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And we get  $FV = -175948.09$ . So she still need to repay 175948.09 PLN.



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Part (c) is done in 2 parts. First we need to see how much she still owes after 10 years:

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$$FV = ? \text{ (how much she still owes)}$$

$$P/Y = 12 \text{ (12 payments per year)}$$

$$C/Y = 12 \text{ (compounded 12 times per year)}$$

And we get  $FV = -175948.09$ . So she still need to repay 175948.09PLN.

## Exam-style question 1c

Now we increase the payments:

$n = ?$  (unknown number of months)

$i\% = 3.5$  (annual interest rate)

$PV = 175948.09$  (positive, she gets this money)

$PMT = -2500$  (increased repayments)

$FV = 0$  (loan is to be repaid)

$P/Y = 12$  (12 payments per year)

$C/Y = 12$  (compounded 12 times per year)

And we get  $n = 78.9$ . So she needs another 79 months to repay the loan.  
The total time to repay the loan is then 199 months ( $120 + 79$ ).

## Exam-style question 1c

Now we increase the payments:

$$n = ? \text{ (unknown number of months)}$$

$$I\% = 3.5 \text{ (annual interest rate)}$$

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$$PMT = -2500 \text{ (increased repayments)}$$

$$FV = 0 \text{ (loan is to be repaid)}$$

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And we get  $n = 78.9$ . So she needs another 79 months to repay the loan.  
The total time to repay the loan is then 199 months (120 + 79).

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$$PMT = -2500 \text{ (increased repayments)}$$

$$FV = 0 \text{ (loan is to be repaid)}$$

$$P/Y = 12 \text{ (12 payments per year)}$$

$$C/Y = 12 \text{ (compounded 12 times per year)}$$

And we get  $n = 78.9$ . So she needs another 79 months to repay the loan. The total time to repay the loan is then 199 months ( $120 + 79$ ).

## Exam-style question 2

Maria invests 50 000 PLN into savings accounts that pays 1.5% annual interest rate compounded monthly. Additionally she puts another 1000 PLN into the account at the end of each month. Tomasz also invests a certain sum into a savings account that pays 1.6% annual interest rate compounded quarterly. He makes no further payments into the account. Calculate how much he needs to invest to have the same amount of money in the account in 5 years.

We will do this in two parts. First we will calculate the amount in Maria's account in 5 years.

## Exam-style question 2

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We will do this in two parts. First we will calculate the amount in Maria's account in 5 years.

## Exam-style question 2

We input:

$n = 60$  (60 months in 5 years)

$i\% = 1.5$  (annual interest rate)

$PV = -50\,000$  (negative, she invests this)

$PMT = -1000$  (also negative)

$FV = ?$  (unknown)

$P/Y = 12$  (12 payments per year)

$C/Y = 12$  (compounded 12 times per year)

And we get  $FV = 116158.62$ .

## Exam-style question 2

We input:

$$n = 60 \text{ (60 months in 5 years)}$$

$$i\% = 1.5 \text{ (annual interest rate)}$$

$$PV = -50\,000 \text{ (negative, she invests this)}$$

$$PMT = -1000 \text{ (also negative)}$$

$$FV = ? \text{ (unknown)}$$

$$P/Y = 12 \text{ (12 payments per year)}$$

$$C/Y = 12 \text{ (compounded 12 times per year)}$$

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We input:

$$n = 60 \text{ (60 months in 5 years)}$$

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$$PMT = -1000 \text{ (also negative)}$$

$$FV = ? \text{ (unknown)}$$

$$P/Y = 12 \text{ (12 payments per year)}$$

$$C/Y = 12 \text{ (compounded 12 times per year)}$$

And we get  $FV = 116158.62$ .

## Exam-style question 2

Now we look at Tomasz:

$n = 60$  (60 months in 5 years)

$i\% = 1.6$  (annual interest rate)

$PV = ?$  (unknown, will be negative)

$PMT = 0$  (no payments)

$FV = 116158.6181$  (what Maria should have)

$P/Y = 4$  (4 periods per year)

$C/Y = 4$  (compounded 4 times per year)

And we get  $PV = -91417.36$ . Tomasz needs to invest 91417.36 PLN to have the same amount as Maria in 5 years.

## Exam-style question 2

Now we look at Tomasz:

$$n = 60 \text{ (60 months in 5 years)}$$

$$I\% = 1.6 \text{ (annual interest rate)}$$

$$PV = ? \text{ (unknown, will be negative)}$$

$$PMT = 0 \text{ (no payments)}$$

$$FV = 116158.6181 \text{ (what Maria should have)}$$

$$P/Y = 4 \text{ (4 periods per year)}$$

$$C/Y = 4 \text{ (compounded 4 times per year)}$$

And we get  $PV = -91417.36$ . Tomasz needs to invest 91417.36 PLN to have the same amount as Maria in 5 years.

## Exam-style question 2

Now we look at Tomasz:

$$n = 60 \text{ (60 months in 5 years)}$$

$$I\% = 1.6 \text{ (annual interest rate)}$$

$$PV = ? \text{ (unknown, will be negative)}$$

$$PMT = 0 \text{ (no payments)}$$

$$FV = 116158.6181 \text{ (what Maria should have)}$$

$$P/Y = 4 \text{ (4 periods per year)}$$

$$C/Y = 4 \text{ (compounded 4 times per year)}$$

And we get  $PV = -91417.36$ . Tomasz needs to invest 91417.36 PLN to have the same amount as Maria in 5 years.

## Not really an exam-style question 3

Tomasz takes a loan of 200 000 PLN. The interest on the loan is 3.2% compounded quarterly. The loan is to be repaid in monthly payments of 1477.74 PLN per month.

- (a) How long does it take to repay the loan?
- (b) Calculate the total interest on the loan.
- (b) After 5 years the bank decreases the interest on the loan to 3% how much quicker will Tomasz repay his loan given that the repayments are not changed?

This is an unusual question, because  $P/Y \neq C/Y$ . I don't think a question like this will be on the exam, however you should be prepared just in case.

## Not really an exam-style question 3

Tomasz takes a loan of 200 000 PLN. The interest on the loan is 3.2% compounded quarterly. The loan is to be repaid in monthly payments of 1477.74 PLN per month.

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This is an unusual question, because  $P/Y \neq C/Y$ . I don't think a question like this will be on the exam, however you should be prepared just in case.

## Exam-style question 3a

Our input:

$n = ?$  (unknown number of months)

$i\% = 3.2$  (annual interest rate)

$PV = 200\,000$  (positive, he gets the money)

$PMT = -1477.74$  (negative, he gives the money back)

$FV = 0$  (loan is repaid)

$P/Y = 12$  (12 payments per year)

$C/Y = 4$  (compounded 4 times per year)

And we get  $n = 168$ . So the loan will be repaid in 168 months or 14 years.

## Exam-style question 3a

Our input:

$$n = ? \text{ (unknown number of months)}$$

$$I\% = 3.2 \text{ (annual interest rate)}$$

$$PV = 200\,000 \text{ (positive, he gets the money)}$$

$$PMT = -1477.74 \text{ (negative, he gives the money back)}$$

$$FV = 0 \text{ (loan is repaid)}$$

$$P/Y = 12 \text{ (12 payments per year)}$$

$$C/Y = 4 \text{ (compounded 4 times per year)}$$

And we get  $n = 168$ . So the loan will be repaid in 168 months or 14 years.



## Exam-style question 3a

Our input:

$$n = ? \text{ (unknown number of months)}$$

$$I\% = 3.2 \text{ (annual interest rate)}$$

$$PV = 200\,000 \text{ (positive, he gets the money)}$$

$$PMT = -1477.74 \text{ (negative, he gives the money back)}$$

$$FV = 0 \text{ (loan is repaid)}$$

$$P/Y = 12 \text{ (12 payments per year)}$$

$$C/Y = 4 \text{ (compounded 4 times per year)}$$

And we get  $n = 168$ . So the loan will be repaid in 168 months or 14 years.

## Exam-style question 3b

Total interest is:

$$168 \cdot 1477.74 - 200000 = 48260.32$$

Because he pays 1477.74 PLN for 168 months for a loan of 200 000 PLN.

## Exam-style question 3b

Total interest is:

$$168 \cdot 1477.74 - 200000 = 48260.32$$

Because he pays 1477.74 PLN for 168 months for a loan of 200 000 PLN.

## Exam-style question 3c

We first calculate how much he still owes after 5 years:

$n = 60$  (60 months in 5 years)

$i\% = 3.2$  (annual interest rate)

$PV = 200\,000$  (positive, he gets the money)

$PMT = -1477.74$  (negative, he gives the money back)

$FV = ?$  (unknown)

$P/Y = 12$  (12 payments per year)

$C/Y = 4$  (compounded 4 times per year)

And we get  $FV = -138560.3338$ .

## Exam-style question 3c

We first calculate how much he still owes after 5 years:

$$n = 60 \text{ (60 months in 5 years)}$$

$$i\% = 3.2 \text{ (annual interest rate)}$$

$$PV = 200\,000 \text{ (positive, he gets the money)}$$

$$PMT = -1477.74 \text{ (negative, he gives the money back)}$$

$$FV = ? \text{ (unknown)}$$

$$P/Y = 12 \text{ (12 payments per year)}$$

$$C/Y = 4 \text{ (compounded 4 times per year)}$$

And we get  $FV = -138560.3338$

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We first calculate how much he still owes after 5 years:

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$$PV = 200\,000 \text{ (positive, he gets the money)}$$

$$PMT = -1477.74 \text{ (negative, he gives the money back)}$$

$$FV = ? \text{ (unknown)}$$

$$P/Y = 12 \text{ (12 payments per year)}$$

$$C/Y = 4 \text{ (compounded 4 times per year)}$$

And we get  $FV = -138560.3338$ .

## Exam-style question 3c

Now we decrease the interest rate:

$n = ?$  (unknown)

$i\% = 3$  (new interest rate)

$PV = 138560.3338$  (he still owes this)

$PMT = -1477.74$  (repayments are not changed)

$FV = 0$  (loan is repaid)

$P/Y = 12$  (12 payments per year)

$C/Y = 4$  (compounded 4 times per year)

And we get  $n = 107$ . So the loan takes a total of 167 months to be repaid. He repays it only one month earlier.

## Exam-style question 3c

Now we decrease the interest rate:

$$n = ? \text{ (unknown)}$$

$$I\% = 3 \text{ (new interest rate)}$$

$$PV = 138560.3338 \text{ (he still owes this)}$$

$$PMT = -1477.74 \text{ (repayments are not changed)}$$

$$FV = 0 \text{ (loan is repaid)}$$

$$P/Y = 12 \text{ (12 payments per year)}$$

$$C/Y = 4 \text{ (compounded 4 times per year)}$$

And we get  $n = 107$ . So the loan takes a total of 167 months to be repaid. He repays it only one month earlier.



## Exam-style question 3c

Now we decrease the interest rate:

$$n = ? \text{ (unknown)}$$

$$I\% = 3 \text{ (new interest rate)}$$

$$PV = 138560.3338 \text{ (he still owes this)}$$

$$PMT = -1477.74 \text{ (repayments are not changed)}$$

$$FV = 0 \text{ (loan is repaid)}$$

$$P/Y = 12 \text{ (12 payments per year)}$$

$$C/Y = 4 \text{ (compounded 4 times per year)}$$

And we get  $n = 107$ . So the loan takes a total of 167 months to be repaid. He repays it only one month earlier.

In case of any questions you can email me at [t.j.lechowski@gmail.com](mailto:t.j.lechowski@gmail.com) or message me via Librus.