Financial applications

Money that earns interest on its interest grows geometrically: compound interest is a geometric sequence in disguise. The same formula, with a negative rate, describes depreciation; dividing by the inflation factor gives the real value. On Paper 2 the GDC's finance solver does the arithmetic.

I COMPOUND INTERNEST

SL 1.4 · $FV = PV\left(1+\frac{r}{100k}\right)^{kn}$, the finance solver

I.1 Compound interest, once a year

Definition 1 *compound interest*

PV invested at a nominal annual rate of r %, compounded k times a year, is worth after n years

$$FV = PV \times \left(1+\frac{r}{100k}\right)^{kn}.$$

Yearly $k=1$; half-yearly $k=2$; quarterly $k=4$; monthly $k=12$.

Example 1

2500 euros are invested at 4 % a year, compounded yearly. Find the value after 6 years.

WHAT YOU DO	WHAT YOU WRITE
Step 1 Read PV, r, k, n	$PV=2500$, $r=4$, $k=1$, $n=6$
Step 2 Substitute	$FV = 2500\times 1.04^{6}$
Step 3 Compute, to the cent	3163.30 euros

APPLY

1 1200 euros at 6 % a year for 3 years.

2 800 euros at 2.5 % a year for 10 years.

I.2 Compounded k times a year

Watch out 1

The rate is divided by $100k$, and the power is the number of periods kn, not the number of years. In the finance solver, PV and FV have opposite signs.

Example 2

6000 euros are invested at a nominal annual rate of 4.8 %, compounded monthly. Find the value after 5 years.

WHAT YOU DO	WHAT YOU WRITE
Step 1 Rate per period: $\frac{r}{100k}$	$\frac{4.8}{1200} = 0.004$
Step 2 Number of periods: kn	$12 \times 5 = 60$
Step 3 Substitute and compute	$6000 \times 1.004^{60} = 7623.84$ euros

APPLY

3 3000 euros at 6 %, compounded quarterly, for 4 years.

4 10 000 euros at 3 %, compounded half-yearly, for 2 years.

I.3 Simple or compound

Property 1 *simple and compound*

Simple interest: only the starting sum earns interest, the same amount each year (a line). **Compound** interest: the interest earns interest too (a geometric sequence).

Example 3

1000 euros are invested for 4 years at 6 % a year. Compare simple and compound interest.

WHAT YOU DO	WHAT YOU WRITE
Step 1 Simple: 4 times the same interest	$1000 + 4 \times 60 = 1240$
Step 2 Compound: $\times 1.06$ each year	$1000 \times 1.06^4 = 1262.48$
Step 3 Difference	22.48 euros more with compound interest

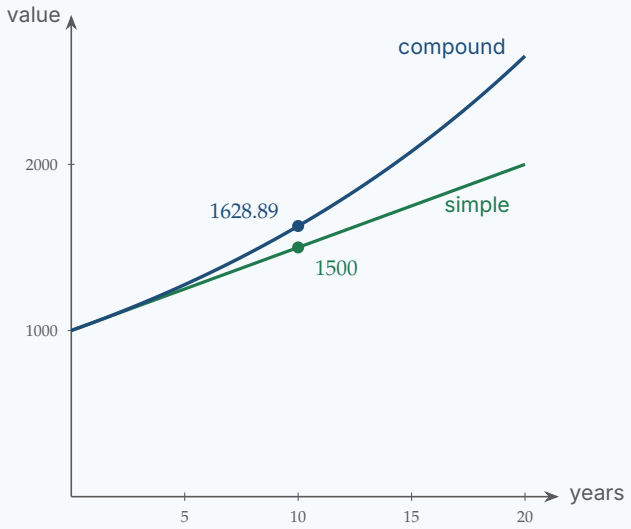


Figure 1 — 1000 at 5 % a year: simple interest reaches 1500 after 10 years, compound interest 1628.89 — the gap of Example 3, growing.

APPLY

5 5000 euros at 3 % for 10 years: simple, then compound.

I.4 n or r unknown: the finance solver

Example 4

4000 euros are invested at 5 % a year, compounded yearly. After how many complete years is the value more than 6000 euros?

WHAT YOU DO	WHAT YOU WRITE
Step 1 Write the inequality	$4000 \times 1.05^n > 6000$
Step 2 Solve on the GDC (solver or table)	$n > 8.31$
Step 3 Round up: complete years	9 years

APPLY

6 The rate, compounded yearly, that makes 2000 euros 2500 euros in 5 years.

7 1500 euros at 3.6 %, compounded monthly: complete years to double.

II.1 Depreciation

Definition 2 *depreciation*

An asset that loses r % of its value each year **depreciates**: $V = V_0\left(1 - \frac{r}{100}\right)^n$. In the finance solver, $I\% = -r$.

Example 5

A laptop costs 1800 euros and depreciates by 22 % a year. Find its value after 3 years.

WHAT YOU DO	WHAT YOU WRITE
Step 1 Multiplier: $1 - \frac{r}{100}$ Not 0.22: that is the part lost.	0.78
Step 2 Substitute	1800×0.78^3
Step 3 Compute	854.19 euros

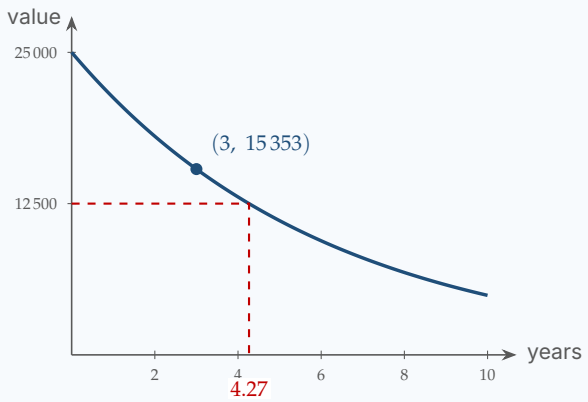


Figure 2 — A car bought for 25 000 euros, depreciating at 15 % a year: half its price after about 4.27 years — the rate of Example 5.

APPLY

1 A machine: 50 000 euros, 10 % a year, after 4 years.

2 A phone: 900 euros, 30 % a year, after 2 years.

II.2 How many complete years?

Watch out 2

"After how many complete years is the value below ...?": solve, round up, and check the year before.

Example 6

A car bought for 18 000 euros depreciates by 15 % a year. After how many complete years is its value below 9000 euros?

WHAT YOU DO	WHAT YOU WRITE
Step 1 Write the inequality	$18\,000 \times 0.85^n < 9000$
Step 2 Solve on the GDC	$n > 4.27$
Step 3 Round up, check the year before	$V_4 = 9396.11$, $V_5 = 7986.70$: 5 years

APPLY

3 2400 euros, 20 % a year: complete years until the value is below 1000 euros.

II.3 Inflation and real value

Property 2 *inflation and real value*

Prices rising by i % a year: FV in n years is worth $\dfrac{FV}{\left(1+\frac{i}{100}\right)^n}$ in today's money, its **real value**. The real rate is about the interest rate minus the inflation rate.

Example 7

Inflation is 2.5 % a year. What are 10 000 euros, received in 5 years, worth in today's money?

WHAT YOU DO	WHAT YOU WRITE
Step 1 The inflation factor over 5 years	1.025^5
Step 2 Divide	$\dfrac{10\,000}{1.025^5}$
Step 3 Compute	8838.54 euros

APPLY

4 A ticket costs 50 euros today; inflation 3 % a year. Its price in 4 years?

5 An account pays 4 %; inflation is 1.5 %. The real rate, approximately?

III EXAM-STYLE QUESTIONS

from the shortest to the longest · every one in steps, with its marks

A Compound interest

EXAM-STYLE QUESTION 1 Paper 2 · calculator · [Maximum mark: 5]

Aiko invests 5000 euros in an account that pays a nominal annual interest rate of 3.5 %, compounded monthly.

(a) Find the value of the investment after 8 years, to the nearest euro. [2]

(b) Find the number of complete years needed for the value to exceed 7000 euros. [3]

WORKING (a)

WHAT YOU DO	WHAT YOU WRITE	
Step 1 Rate $\frac{r}{1200}$, power $12n$	$5000\left(1+\frac{3.5}{1200}\right)^{96}$ *Or the finance solver: $N = 96$, $I\% = 3.5$, $PV = -5000$, $P/Y = C/Y = 12$.*	(M1)
Step 2 Compute	6613 euros $(6612.95\ldots)$	A1

WORKING (b)

WHAT YOU DO	WHAT YOU WRITE	
Step 1 Write the inequality	$5000\left(1+\frac{3.5}{1200}\right)^{12n} > 7000$	(M1)
Step 2 Solve on the GDC	$n > 9.63$ $(9.6275\ldots)$ *Or after 9 years 6848, after 10 years 7092.*	(A1)
Step 3 Round up: complete years	10 years	A1

B Depreciation

EXAM-STYLE QUESTION 2 Paper 2 · calculator · [Maximum mark: 4]

A car is bought for 28 000 euros. Its value decreases by 12 % each year.

(a) Find the value of the car after 5 years, to the nearest euro. [2]

(b) Find the number of complete years after which the value of the car is first less than 10 000 euros. [2]

WORKING (a)

WHAT YOU DO	WHAT YOU WRITE	
Step 1 Multiplier 0.88, power 5	$28\,000 \times 0.88^5$	(M1)
Step 2 Compute	14 776 euros $(14\,776.49\ldots)$	A1

WORKING (b)

WHAT YOU DO	WHAT YOU WRITE	
Step 1 Write the inequality, solve on the GDC	$28\,000 \times 0.88^n < 10\,000,\ n > 8.05$	(M1)
	Or after 8 years 10 070, after 9 years 8 861.	
Step 2 Round up: complete years	9 years	A1

C Without a calculator (Paper 1)

EXAM-STYLE QUESTION 3 — Paper 1 · no calculator · [Maximum mark: 3]

An amount of 2000 euros is invested at 10 % per year, compounded yearly.

(a) Find the value of the investment after 2 years. [2]

(b) Write down an expression for the value after n years. [1]

WORKING (a)

WHAT YOU DO	WHAT YOU WRITE	
Step 1 Multiplier 1.1, power 2	2000×1.1^2	(M1)
Step 2 Compute	$= 2420$ euros	A1

WORKING (b)

WHAT YOU DO	WHAT YOU WRITE	
Step 1 Write $PV \times 1.1^n$	2000×1.1^n	A1

D A rate to find, and inflation

EXAM-STYLE QUESTION 4 — Paper 2 · calculator · [Maximum mark: 5]

Bruno wants 4000 euros to become 5000 euros in 6 years, in an account with interest compounded quarterly.

(a) Find the nominal annual interest rate he needs, to two decimal places. [3]

(b) Inflation is expected to be 2 % per year. Find the real value, in today's money, of 5000 euros in 6 years, to the nearest euro. [2]

WORKING (a)

WHAT YOU DO	WHAT YOU WRITE	
Step 1 Write the equation	$4000\left(1+\frac{r}{400}\right)^{24} = 5000$ *Or the finance solver: $N = 24$, $PV = -4000$, $FV = 5000$, $P/Y = C/Y = 4$.*	M1
Step 2 Solve on the GDC	$r = 3.736\ldots$	(A1)
Step 3 Round to 3 s.f.	3.74 %	A1

WORKING (b)

WHAT YOU DO	WHAT YOU WRITE	
Step 1 Divide by the inflation factor	$\frac{5000}{1.02^6}$	(M1)
Step 2 Compute	4440 euros $(4439.86\ldots)$	A1

IV WHICH METHOD? READ THE QUESTION

1.4 · the whole topic on one page

THE QUESTION SAYS	YOU KNOW	YOU WRITE
"compounded monthly / quarterly"	$k = 12$ or $k = 4$	rate $\frac{r}{100k}$, power kn D1
"find the value after n years"	FV	the formula or the finance solver; units, sensible rounding D1
"how many years until ..."	n unknown	solver or table; round up, check the year before W2
"find the interest rate"	r unknown	the solver gives $I\%$ D1
"depreciates by r %"	multiply by $1 - \frac{r}{100}$	$I\% = -r$ in the solver D2
"in today's money", "real value"	divide by the inflation factor	$\frac{FV}{(1+i/100)^n}$ P2
simple or compound?	line or geometric sequence	compound unless the question says simple P1

In the exam 1 *command terms*

Nearest euro, two decimal places: money is rounded as asked, not to 3 s.f. **Complete years**: a whole number, rounded up. **Nominal annual rate**: the yearly rate before it is divided by k.

V ON THE GDC: PAPER 2

SL 1.4 · NumWorks · every calculator move of this topic

1 The finance solver

Finance → Simple / Compound interest → Compound → solve for FV

Leave the unknown empty and solve for it; PV negative (money paid in).
On paper: the values entered, then $FV = 6613$ euros.

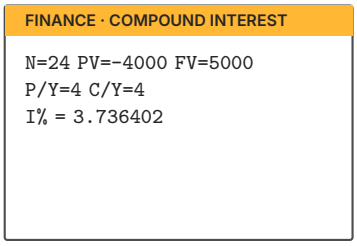
FINANCE · COMPOUND INTEREST

```
N=96 I%=3.5 PV=-5000
Pmt=0 P/Y=12 C/Y=12
FV = 6612.953
```

2 An unknown rate

Finance → Compound → solve for I%

The same screen, solved for $I\%$. **On paper:** "$I\% = 3.74$", a nominal annual rate.



ANSWERS TO THE APPLY QUESTIONS

I.1 1429.22 euros

I.2 1024.07 euros

I.3 3806.96 euros

I.4 10 613.64 euros

I.5 6500; 6719.58 euros

I.6 4.56 %

I.7 $n > 19.3$: 20 years

II.1 32 805 euros

II.2 441 euros

II.3 4 years (983.04)

II.4 56.28 euros

II.5 2.5 %

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