

## 2. The Time Value of Money

### Problem 4

Suppose you deposit \$100 in the bank today and it earns interest at a rate of 10% compounded annually. How much will be in the account 50 years from today?

#### Solution

In this case, \$100 invested at 10-percent for 50 years accumulates to

$$FV = PV(1+i)^n = 11739,1$$

### Problem 5

How much money must you deposit in a savings account today to have \$10,000 10 years from today if the interest rate is 5% compounded annually ?

#### Solution

$$PV = FV \frac{1}{(1+i)^n} = 6,139$$

### Problem 6

A stock has paid dividends regularly for the last 10 years, starting with a \$1 dividend in 1997 and increasing to \$8 in 2007. If these dividends have been growing at a constant rate, what has that rate been for the last 10 years?

#### Solution

The exact answer is obtained by solving for  $i$  in the expression  $(1+i)^{10}=8$ ; the equation holds when  $i = 8^{0.1} - 1 = 23,11\%$

$$i = \sqrt[n]{\frac{FV}{PV}} - 1 = 23,11\%$$

### Problem 7

Your sister borrows \$1 and promises to repay \$1,5. If you want at least a 6% return on your loan, within how many years must she pay you back?

#### Solution

The exact answer is obtained by solving for "n" in the expression  $(1,06)^n=1,5$ ; Taking the natural log of both sides and rearranging,

$$n = \frac{\ln \frac{FV}{PV}}{\ln(1+i)} = 6,96 \text{ years}$$

$$n = (\ln 1.5 / \ln 1.06) = 6,96 \text{ years.}$$

**Problem 8**

Compare the future value in one year of \$100,000 to be invested today at 10% under the following scenarios.

- (a) Annual compounding
- (b) Quarterly compounding
- (c) Continuous compounding

**Solution**

(a)	$100,000 * (1 + 10\%)^1 =$	110,000
(b)	$100,000 * (1 + 2.5\%)^4 =$	110,381
(c)	$100,000 * e^{10\%} =$	110,517

**Problem 9**

An annuity due (or rent annuity) is an annuity whose payments are made at the beginning of each period. What is the present value of a 20-year annuity due with \$1000 payments if the discount rate is 5%?

**Solution**

$$PVA = 1000 + 1000 (PVFA_{0.05,19})$$

$$1000 + 12085 = 13085.$$

Twenty payments of \$1000 made at the beginning of each year is the same as \$1000 received now and an ordinary annuity of \$1,000 received at the end of years 1,2,...,19.

**Problem 10**

Which of the following perpetuities represents the largest present value?

<i>Perpetuity</i>	<i>Annual amount (\$)</i>	<i>Discount rate (%)</i>
A	100,000	5,0%
B	120,000	6,0%
C	160,000	8,0%
D	200,000	10,0%

**Solution**

A	B	C	D
2 000,000	2 000,000	2 000,000	2 000,000

**Problem 11**

Calculate the present value of a growing annuity that starts off with a payment of \$100 and the subsequent annual payments grow at the annual rate of 8%. The discount rate is 10%, and the security makes a total of 5 payments.

**Solution**

Value of annuity

$$PV = \frac{PMT_1}{i - g} \left[ 1 - \left( \frac{1 + g}{1 + i} \right)^n \right] = 438,31$$

**Problem 12**

A bond pays \$50 interest every year plus \$1000 when it matures in 12 years. You can buy the bond today for \$950. What is the internal rate of return of this investment ?

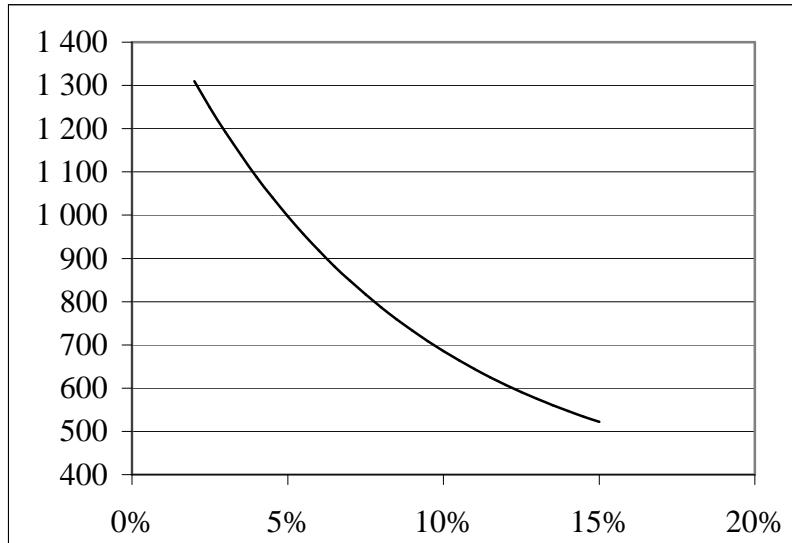
**Solution**

The YTM (internal rate of return) discounts the cash flows to the current market price.

0	1	2	3	4	5	6	7	8	9	10	11	12
-950	50	50	50	50	50	50	50	50	50	50	50	1 050

$$\text{IRR} = 5.58\%$$

Rate	Price
2.0%	1 310
2.5%	1 249
3.0%	1 192
3.5%	1 138
4.0%	1 088
4.5%	1 041
5.0%	998
5.5%	957
6.0%	918
6.5%	882
7.0%	848
7.5%	817
8.0%	787
8.5%	759
9.0%	733
9.5%	709
10.0%	686
10.5%	664
11.0%	644
11.5%	625
12.0%	607
12.5%	591
13.0%	575
13.5%	561
14.0%	547
14.5%	534
15.0%	522



**Problem 13**

Loan amount \$	100,000
Interest rate	12% per year
Period	1 year, monthly equal payments
Provision	2%

(a) Show the loan amortization schedule.

(b) Calculate the effective interest rate with and without a provision \$2,000.

**Solution**

(a)

$$PV = \frac{PMT}{(1+i)^1} + \frac{PMT}{(1+i)^2} + \dots + \frac{PMT}{(1+i)^n} = PMT \frac{1 - \left[ \frac{1}{(1+i)^n} \right]}{i} = PMT \frac{(1+i)^n - 1}{i(1+i)^n}$$

Period	Payment	Interest	Principal paid off	Remaining principal
0				100,000
1	8,885	1,000	7,885	92,115
2	8,885	0,921	7,964	84,151
3	8,885	0,842	8,043	76,108
4	8,885	0,761	8,124	67,984
5	8,885	0,680	8,205	59,779
6	8,885	0,598	8,287	51,492
7	8,885	0,515	8,370	43,122
8	8,885	0,431	8,454	34,668
9	8,885	0,347	8,538	26,130
10	8,885	0,261	8,624	17,506
11	8,885	0,175	8,710	8,796
12	8,885	0,088	8,797	0

(b)

0	-100,000	-98,000
1	8,885	8,885
2	8,885	8,885
3	8,885	8,885
4	8,885	8,885
5	8,885	8,885
6	8,885	8,885
7	8,885	8,885
8	8,885	8,885
9	8,885	8,885
10	8,885	8,885
11	8,885	8,885
12	8,885	8,885
IRR =	12,0%	15,9%

**Problem 14**

Brew Corporation is considering two alternative bond issues. In option 1, Brew will make interest payments indefinitely at the rate of 5%. Under option 2, Brew will make the first interest payment in one year's time at 4%, but subsequent payments will increase at 3%. The discount rate is 6%. Which option should Brew choose? Assume that Brew borrows the same amount under each alternative.

**Solution**

$$\text{Option 1 } 833,333 = 5\% * 1000 / 6\%$$

$$\text{Option 2 } 1333,33 = 4\% * 1000 / (6\% - 3\%)$$

Option 1 is better, since they are receiving \$1,000 in exchange for promised payments worth only \$833.