vrije Universiteit amsterdam

Faculty of Economics and Business Administration

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| Exam: | Investments 3.4 |
| Code: | E_EBE3_INV |
| Coordinator: | dr. D. Stefanova |
| Date: | May 21, 2012 |
| Time: | 8.45 |
| Duration: | 2 hours and 45 minutes |
| Calculator allowed: | Yes |
| Graphical calculator allowed: | Yes |
| Number of questions: | 20 multiple choice questions and 4 open questions |
| Type of questions: | Open/ multiple choice |
| Answer in: | English |

Remarks: Be concise and complete in your answers (including calculations). Always explain your answers, even if not explicitly called for. Use your time efficiently, using the maximum number of points per question as a guideline.

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| Credit score: | The maximum possible scores for each part and question are indicated. In total, you can earn 100 points. Your final exam grade is determined by dividing the number of points by 10. |
| Grades: | The grades will be made public on: June 1 2012. |
| Inspection: | Friday, June 1 2012 at 10.00 in room 2A-33. |
| Number of pages: | 12 (including front page) |

**Good luck!**

**PART 1 (MULTIPLE CHOICE; 40 points at maximum)**

**Read the questions and answers carefully and write down your answer on your answer sheet. Your final score is determined as (# correct answers - 2) * 40/18. Negative scores for this part of the exam are set to zero.**

1. According to the Capital Asset Pricing Model (CAPM), underpriced securities

A. have positive betas.

B. have zero alphas.

C. have negative betas.

**D.** have positive alphas.

E. have negative alphas.

According to the Capital Asset Pricing Model (CAPM), underpriced securities have positive alphas.

2. You invest $600 in a security with a beta of 1.2 and $400 in another security with a beta of 0.90. The beta of the resulting portfolio is

A. 1.40

B. 1.00

C. 0.36

**D.** 1.08

E. 0.80

0.6(1.2) + 0.4(0.90) = 1.08.

3. The amount that an investor allocates to the market portfolio is negatively related to

I) The expected return on the market portfolio.

II) The investor's risk aversion coefficient.

III) The risk-free rate of return.

IV) The variance of the market portfolio

A. I and II

B. II and III

C. II and IV

**D.** II, III, and IV

E. I, III, and IV

The optimal proportion is given by $y = (E(R_M)-r_f)/(.01xA\sigma^2_M)$. This amount will decrease as $r_f$, A, and $\sigma^2_M$ decrease.

4. Consider the one-factor APT. The variance of returns on the factor portfolio is 6%. The beta of a well-diversified portfolio on the factor is 1.1. The variance of returns on the well-diversified portfolio is approximately __________.

A. 3.6%

B. 6.0%

**C.** 7.3%

D. 10.1%

E. 8.6%

$s^2_P = (1.1)^2(6\%) = 7.26\%$.

5. In the APT model, what is the nonsystematic standard deviation of an equally-weighted portfolio that has an average value of $\sigma(e_i)$ equal to 18% and 250 securities?

**A.** 1.14%

B. 625%

C. 0.5%

D. 3.54%

E. 3.16%

Wrong, rewrite, sqrt(1.296) = 1.138%

$$\sigma^2(e_p) = \frac{1}{n}\bar{\sigma}^2(e_i) = \frac{1}{250}(18)^2 = 1.296, \quad \sigma(e_p) = \sqrt{10.0} = 1.138\%$$

6. An investor who wishes to form a portfolio that lies to the right of the optimal risky portfolio on the Capital Allocation Line must:

A. lend some of her money at the risk-free rate and invest the remainder in the optimal risky portfolio.

B. borrow some money at the risk-free rate and invest in the optimal risky portfolio.

C. invest only in risky securities.

D. such a portfolio cannot be formed.

**E.** both borrow some money at the risk-free rate and invest in the optimal risky portfolio and invest only in risky securities

The only way that an investor can create a portfolio that lies to the right of the Capital Allocation Line is to create a borrowing portfolio (buy stocks on margin). In this case, the investor will not hold any of the risk-free security, but will hold only risky securities.

7. The individual investor's optimal portfolio is designated by:
**A.** The point of tangency with the indifference curve and the capital allocation line.
B. The point of highest reward to variability ratio in the opportunity set.
C. The point of tangency with the opportunity set and the capital allocation line.
D. The point of the highest reward to variability ratio in the indifference curve.
E. None of these is correct.

The indifference curve represents what is acceptable to the investor; the capital allocation line represents what is available in the market. The point of tangency represents where the investor can obtain the greatest utility from what is available.

8. Consider an investment opportunity set formed with two securities that are perfectly negatively correlated. The global minimum variance portfolio has a standard deviation that is always
A. greater than zero.
**B.** equal to zero.
C. equal to the sum of the securities' standard deviations.
D. equal to -1.
E. between zero and -1.

If two securities were perfectly negatively correlated, the weights for the minimum variance portfolio for those securities could be calculated, and the standard deviation of the resulting portfolio would be zero.

9. Fools Gold Mining Company is expected to pay a dividend of $8 in the upcoming year. Dividends are expected to decline at the rate of 2% per year. The risk-free rate of return is 6% and the expected return on the market portfolio is 14%. The stock of Fools Gold Mining Company has a beta of -0.25. The return you should require on the stock is _______.

A. 2%
**B.** 4%
C. 6%
D. 8%
E. None of these is correct

6% + [-0.25(14% - 6%)] = 4%.

10. The following data are available relating to the performance of Sooner Stock Fund and the market portfolio:

| | Sooner | Market Portfolio |
|---|---|---|
| Average Return | 20% | 11% |
| Standard Deviation of Returns | 44% | 19% |
| Beta | 1.8 | 1.0 |
| Residual standard deviation | 2.0% | 0.0% |

The risk-free return during the sample period was 3%. What is the Sharpe measure of performance evaluation for Sooner Stock Fund?

A. 1.33%
B. 4.00%
C. 8.67%
**D.** 38.6%
E. 37.14%

(20% - 3%)/44% = 0.386, or 38.6%.

11. You have just purchased a 10-year zero-coupon bond with a yield to maturity of 10% and a par value of $1,000. What would your rate of return at the end of the year be if you sell the bond? Assume the yield to maturity on the bond is 11% at the time you sell.
A. 10.00%
B. 20.42%
C. 13.8%
**D.** 1.4%
E. None of these is correct.

$1,000/(1.10)10 = $385.54; $1,000/(1.11)9 = $390.92; ($390.92 - $385.54)/$385.54 = 1.4%.

12. Consider a 5-year bond with a 10% coupon that has a present yield to maturity of 8%. If interest rates remain constant, one year from now the price of this bond will be _______.
A. higher
**B.** lower
C. the same
D. cannot be determined
E. $1,000

This bond is a premium bond as interest rates have declined since the bond was issued. If interest rates remain constant, the price of a premium bond declines as the bond approaches maturity.

13. Which of the following combinations will result in a sharply increasing yield curve?
**A.** Increasing future expected short rates and increasing liquidity premiums
B. Decreasing future expected short rates and increasing liquidity premiums
C. Increasing future expected short rates and decreasing liquidity premiums
D. Increasing future expected short rates and constant liquidity premiums
E. Constant future expected short rates and increasing liquidity premiums

Both of the forces will act to increase the slope of the yield curve.

14. Which of the following two bonds is more price sensitive to changes in interest rates?
1) A par value bond, X, with a 5-year-to-maturity and a 10% coupon rate.
2) A zero-coupon bond, Y, with a 5-year-to-maturity and a 10% yield-to-maturity.
A. Bond X because of the higher yield to maturity.
B. Bond X because of the longer time to maturity.
**C.** Bond Y because of the longer duration.
D. Both have the same sensitivity because both have the same yield to maturity.
E. None of these is correct.

Duration is the best measure of bond price sensitivity; the longer the duration the higher the price sensitivity. Bond Y has a longer duration.

15. Some of the problems with immunization are
A. duration assumes that the yield curve is flat.
B. duration assumes that if shifts in the yield curve occur, these shifts are parallel.
C. immunization is valid for one interest rate change only.
D. durations and horizon dates change by the same amounts with the passage of time.
**E.** duration assumes that the yield curve is flat, duration assumes that if shifts in the yield curve occur, these shifts are parallel, and immunization is valid for one interest rate change only.

Durations and horizon dates change with the passage of time, but not by the same amounts.

16. The current market price of a share of Disney stock is $30. If a call option on this stock has a strike price of $35, the call
**A.** is out of the money.
B. is in the money.
C. can be exercised profitably.
D. is out of the money and can be exercised profitably.
E. is in the money and can be exercised profitably.

If the striking price on a call option is more than the market price, the option is out of the money and cannot be exercised profitably.

17. According to the put-call parity theorem, the value of a European put option on a non-dividend paying stock is equal to:

A. the call value plus the present value of the exercise price plus the stock price.

**B.** the call value plus the present value of the exercise price minus the stock price.

C. the present value of the stock price minus the exercise price minus the call price.

D. the present value of the stock price plus the exercise price minus the call price.

E. None of these is correct.

P = C - SO + PV(X) + PV(dividends), where SO = the market price of the stock, and X = the exercise price.

18. Other things equal, the price of a stock put option is positively correlated with the following factors **except**

**A.** the stock price.

B. the time to expiration.

C. the stock volatility.

D. the exercise price.

E. None of these is correct.

The put option price is negatively correlated with the stock price.

19. Delta neutral

A. is the volatility level for the stock that the option price implies.

B. is the continued updating of the hedge ratio as time passes.

C. is the percentage change in the stock call option price divided by the percentage change in the stock price.

**D.** means the portfolio has no tendency to change value as the underlying portfolio value changes.

E. is the volatility level for the stock that the option price implies and is the percentage change in the stock call option price divided by the percentage change in the stock price.

Delta neutral means the portfolio has no tendency to change value as the underlying portfolio value changes.

20. Portfolio A consists of 500 shares of stock and 500 calls on that stock. Portfolio B consists of 800 shares of stock. The call delta is 0.6. Which portfolio has a higher dollar exposure to a change in stock price?

A. Portfolio B.

B. Portfolio A.

**C.** The two portfolios have the same exposure.

D. A if the stock price increases and B if it decreases.

E. B if the stock price decreases and A if it increases.

500 calls (0.6) = 300 shares + 500 shares = 800 shares; 800 shares = 800 shares.

**PART 2 (OPEN QUESTIONS; 60 points at maximum)**

**QUESTION 1. (15 points) Equilibrium pricing models**

**Part a. (3 points)**

What is the expected return of a zero-beta security? Discuss the Black's zero-beta CAPM. Give a graphic interpretation.

$E(R_S) = r_f + 0(R_M - r_f) = r_f$.

The zero-beta CAPM applies in the absence of a risk-free rate. The zero-beta portfolio on the inefficient part of the frontier assumes the role of a risk-free asset in the traditional CAPM. Returns on the efficient frontier can then be expressed as a linear combinaion of any two frontier portfolios, including the market and the zero-beta portfolio.

**Part b. (2 points)**

Explain the separation property of a portfolio selection problem.

The portfolio choice problem may be separated into two independent tasks: determination of the optimal portfolio that does not depend on individual investor's preferences and allocation of the portfolio between risk-free and risky assets, which depends on the risk aversion of the investor.

**Part c. (4 points)**

You have a sample of n stocks with returns $r_i$, and the risk-free rate is given by $r_f$. You want to test some of the implications of the CAPM using the following regression :

$$\widehat{r_i - r_f} = \gamma_0 + \gamma_1\beta_i + \gamma_2\sigma^2(e_i), i = 1, \dots, n$$

Where $\widehat{r_i - r_f}$ is the average excess return of stock i, $\beta_i$ is its beta coefficient, and $\sigma^2(e_i)$ is the variance of its non-systematic risk.

i. The above equation is known as a second-pass regression equation. Give the equation of the first-pass regression. What is its output?

A time-series regression for each stock:
$r_{it} - r_{ft} = \alpha_i + \beta_i(r_{Mt} - r_{ft}) + e_i, i = 1, \dots, n$
$\beta_i$'s from this regression enter the second-pass cross-section regression above.

ii. State the hypotheses concerning the $\gamma$ coefficients if the CAPM is valid. Explain.

$\gamma_0 = 0, \gamma_1 = \overline{r_{Mt} - r_{ft}}, \gamma_2 = 0$

**Part d. (6 points)**

Consider the multifactor APT. There are two independent economic factors, $F_1$ and $F_2$. The risk-free rate of return is 3%. The following information is available about two well-diversified portfolios A and B:

| Portfolio | beta on F1 | beta on F2 | expected return | variance |
|---|---|---|---|---|
| A | 0.5 | 1 | 15% | 20% |
| B | 0 | 2 | 10% | 15% |

i. Assuming no arbitrage opportunities exist, calculate the risk premia on the two factor portfolios

The risk premia of the two factors solve the following system of equations:
15% = 3% + 0.5 RP1 + RP2
10 = 3% + 2 RP2
Thus RP2 = 3.5%, RP1 = 17%

ii. Give an expression for the variance of a well diversified portfolio along the lines of the multifactor APT. Calculate the variance of the two factors, given the data above.

Given the fact that A and B are well-diversified portfolios, the variances of the two factors satisfy the following system of equations:

$$\beta_{A1}^2\sigma_{F1}^2 + \beta_{A2}^2\sigma_{F2}^2 = \sigma_A^2$$
$$\beta_{B1}^2\sigma_{F1}^2 + \beta_{B2}^2\sigma_{F2}^2 = \sigma_B^2$$
$$or:$$
$$0.5^2\sigma_{F1}^2 + 1^2\sigma_{F2}^2 = 0.20^2$$
$$2^2\sigma_{F2}^2 = 0.15^2$$

iii. Construct a portfolio of A and B that has exposure of 1 to F1. What is its exposure to F2?

The weights $w_A$ and $w_B$ in A and B of the portfolio should satisfy the following system of equations:
wA + wB = 1
0.5 x wA + 0 x wB = 1 (exposure of 1 to F1 for the final portfolio)
Thus wA = 2,wB = -1
The exposure to F2 of this portfolio is then: 1 x wA + 2 x wB = 1 x 2 + 2 x (-1) = 0

**QUESTION 2. (15 points) Portfolio construction and performance measurement**

**Part a. (6 points)**

Consider a portfolio P of a risky and a risk-free asset. The expected return of the risky asset is E[r], and its variance is given by $s^2$. The expected return of the risk-free asset is given by $r_f$. The weight of the risky asset in the portfolio is given by w.

i. What are the expected rate of return and the standard deviation of the portfolio P?

Expected rate of return of P: $E[r_P] = wE[r] + (1-w)r_f$; standard deviation of P: $s_P = w*s$

ii. Consider an investor with the following mean-variance utility function: $U = E(r_P) - (A/2)s_P^2$, where $E(r_P)$ is the expected return of a portfolio, $s_P^2$ is its variance, and A is the coefficient of risk aversion. Solve for the optimal allocation to the risky asset for an investor who maximizes this utility function.

The investor solves the following problem: $\max U = r_f + w(E[r]-r_f)-(A/2)w^2s^2$. Setting the first derivative to zero, we obtain the optimal allocation to the risky asset: $w^* = (E[r]-r_f)/(As^2)$.

iii. Given the utility function in (ii), give an expression for A that would make the investor indifferent between investing in the risky portfolio P and the risk-free asset.

For the investor to be indifferent between the risky portfolio and the risky-free asset, the following must hold: $E(r_P) - (A/2)s_P^2 = r_f$, thus for A we obtain: : $A = 2\,(E(r_P) – r_f)/\,s_P^2$.

**Part b. (2 points)**

Discuss the characteristics of **indifference curves**, and the theoretical value of these curves in the portfolio building process.

**Indifference curves** represent the trade-off between two variables. In portfolio building, the choice is between risk and return. The investor is indifferent between all possible portfolios lying on one indifference curve. However, indifference curves are contour maps, with all curves parallel to each other. The curve plotting in the most northwest position is the curve offering the greatest utility to the investor. However, this most desirable curve may not be attainable in the market place. The point of tangency between an indifference curve (representing what is desirable) and the capital allocation line (representing what is possible), is the optimum portfolio for that investor.

**Part c. (4 points)**

You invest $1000 in a risky asset with an expected rate of return of 0.17 and a standard deviation of 0.40 and a T-bill with a rate of return of 0.04.

i. What percentages of your money must be invested in the risky asset and the risk-free asset, respectively, to form a portfolio with an expected return of 0.11?

11% = $w_1$(17%) + (1 - $w_1$)(4%); 11% = 17%$w_1$ + 4% - 4%$w_1$; 7% = 13%$w_1$; $w_1$ = 0.538; 1 - $w_1$ = 0.462.

ii. What percentages of your money must be invested in the risk-free asset and the risky asset, respectively, to form a portfolio with a standard deviation of 0.20?

0.20 = x(0.40); x = 50% in risky asset.

iii. What is the slope of the Capital Allocation Line formed with the risky asset and the risk-free asset?

(0.17 - 0.04)/0.40 = 0.325

**Part d. (3 points)**

You want to evaluate three mutual funds using the information ratio measure for performance evaluation. The risk-free return during the sample period is 6%, and the average return on the market portfolio is 19%. The average returns, residual standard deviations, and betas for the three funds are given below.

| | Average Return | Residual Standard Deviation | Beta |
|---|---|---|---|
| Fund A | 20% | 4.00% | 0.8 |
| Fund B | 21% | 1.25% | 1.0 |
| Fund C | 23% | 1.20% | 1.2 |

Give an expression of the information ration measure. Select the fund with the highest information ratio measure.

Information ratio = $\alpha_P/\sigma(e_P)$; A: $\alpha_P$ = 20 - 6 - .8(19 - 6) = 3.6; 3.6/4 = 0.9; B: $\alpha_P$ = 21 - 6 - 1(19 - 6) = 2.0; 2/1.25 = 1.6; C: $\alpha_P$ = 23 - 6 - 1.2(19 - 6) = 1.4; 1.4/1.20 = 1.16. Thus, fund B.

| QUESTION 3. (15 points) Fixed Income |
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**Part a. (4 points)**

You are given data on the following two 2-year coupon bonds with annual coupon payments and face value of 100.

| Bond | Maturity | Coupon | Price | Yield to maturity | Notional |
|---|---|---|---|---|---|
| A | 2 | 6% | $ 107.2574 | 2.2487 % | $ 100 |
| B | 2 | 3% | $ 101.4057 | 2.2732 % | $ 100 |

Calculate the price of a 2-year zero coupon bond.

A portfolio of a short position in 1 type A bond and a long position in 2 type B bond is a zero-coupon bond, so that: $-P_A + 2P_B = \frac{100}{(1+z_2)^2}$. It directly follows from here that the price of a 2-year zero is -107.2574+2*101.4057 = 95.554.

Otherwise:
The prices of bond A and B can be expressed as: $P_A = \frac{6}{1+z_1} + \frac{106}{(1+z_2)^2}$ and $P_B = \frac{3}{1+z_1} + \frac{103}{(1+z_2)^2}$

From there we solve for $z_2 = 2.3\%$

Hence the price of a 2-year zero: $P_Z = \frac{100}{(1+z_2)^2} = 95.55$

**Part b. (9 points)**

Using the data on the coupon bonds in Part (a) and the rate of the zero-coupon bond you solved for:

i. Compute the modified duration and the convexity of bonds A and B, and the zero-coupon bond. NB. If you have not solved Part (a), assume a zero rate of 2% and solve using it.

Bond A: Duration(A) = $(6/(1+0.0225) * 1 + 106/(1+0.0225)^2 * 2)/107.2574 = 1.95$
Modified duration(A) = 1.95/(1+0.0225) = 1.90
Convexity(A) = $(6/(1+0.0225)/(107.2574*(1+0.225)^2)*(1+1^2) + (106/(1+0.0225^2)/(107.2574*(1+0.225)^2)*(2+2^2) = 5.53$
Bond B: Duration(B) = $(3/(1+0.0227) * 1 + 103/(1+0.0227)^2 * 2)/101.4057 = 1.97$
Modified duration(B) = 1.97/(1+0.0227) = 1.93

Convexity(B) = $(3/(1+0.0227)/(101.4057*(1+0.227)^2)*(1+1^2)$ + $(103/(1+0.0227^2)/(101.4057*(1+0.227)^2)*(2+2^2)$ = 5.63

Zero-coupon bond: Duration = 2

Modified duration = 2/(1+0.023) = 1.96

Convexity = $1/(P*(1+y)^2) * 100*(T^2+T)/(1+y)^T = 1/(P*(1+y)^2) * P*(T^2+T) = (T^2+T)/(1+y)^2$, where T is maturity, P is the price of the bond and y is the yield. Convexity = 5.73

ii. Construct a portfolio that consists of a long position in 100 type A bonds, and a short position in 50 2-year zero coupon bonds. Obtain the value of the portfolio, and the weights of each bond. Calculate the modified duration and convexity of the portfolio.

The value of the portfolio: 100*107.257 – 50*95.604 = 5945.5
Weight of bond A: 100*107.257 /5945.5= 1.804
Weight of the zero-coupon bond: – 50*95.604 /5945.5= -0.804
Portfolio modified duration = 1.804*1.90 – 0.804*1.96 = 1.86
Portfolio convexity = 1.804*5.53 – 0.804*5.73 = 5.37

iii. What should the weight in type A bonds should be in the portfolio in (ii), so that you achieve immunization?

x*1.90 +(1-x)*1.96 = 0, 0.06x = 1.96, x=32.7

iv. You have a callable bond position with modified duration 3 and convexity 9. Form a portfolio of the two coupon bonds and the zero-coupon bond that hedges the callable bond position. Do not solve explicitly for the weights of the hedging portfolio, provide only the system of equations that allows you to solve.

Denote by x1, x2 and x3 the weights in A, B and the zero-coupon bond. Then:
1.90x1 + 1.93x2 + 1.96x3 = 3
5.53x1 + 5.63x2 + 5.73x3 = 9
x1 + x2 + x3 = 1

**Part c. (2 points)**

Suppose that all investors expect that interest rates for the 4 years will be as follows:

| Year | Forward rate |
|---|---|
| 0 (today) | 2% |
| 1 | 4% |
| 2 | 5% |
| 3 | 6% |

What is the price of 3-year zero coupon bond with a par value of $100?

$100 / (1.02)(1.04)(1.05) = $89.78

## QUESTION 4. (15 points) Option pricing

**Part a. (2 points)**

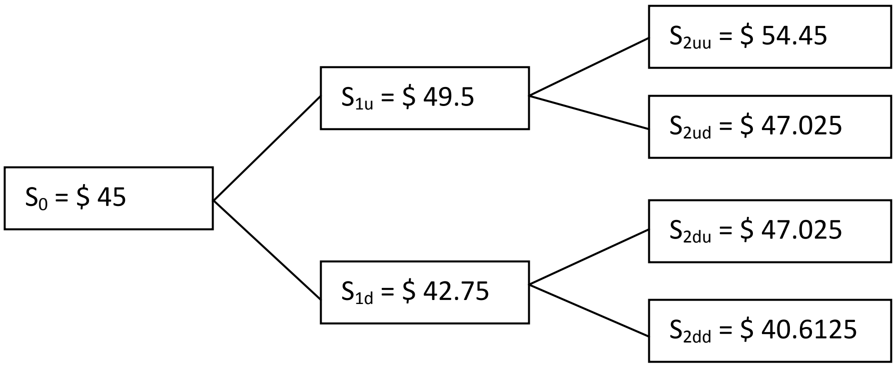
Discuss the relationship between option prices and time to expiration, volatility of the underlying stocks, and the exercise price.

The longer the time to expiration, the higher the premium because it is more likely that an option will become more valuable (more time for the stock price to change). The greater the volatility of the underlying stock, the greater the option premium; the more volatile the stock, the more likely it is that the option will become more valuable (e. g., move from an out of the money to an in the money option, or become more in the money). For call options, the lower the exercise price, the more valuable the option, as the option owner can buy the stock at a lower price. For a put option, the lower the exercise price, the less valuable the option, as the owner of the option may be required to sell the stock at a lower than market price.

**Part b. (7 points)**

Consider the following binomial tree for the evolution of the stock price over the period of 1 year, assuming 2 steps (t=0, t=1, t=2). The stock price can increase by 10% or decrease by 5% each period. The annual risk-free rate is 1%.

i. Calculate the risk-neutral probability of an upward move.




The risk neutral probability Q is related to the risk free rate through: $Q = (S_0*(1+rf)-S_{dn})/(S_{up} - S_{dn})$, thus Q = 36.67%.

ii. Compute the price of the following look-back call option with a *fixed strike price* at $ 45. It pays the maximum of 0 and M, where M is the difference between the *highest* stock price during the life of the option and the strike price.

The price of the look-back option with a fixed strike can be obtained using the risk-neutral probabilities as follows:

At time t=2 the prices are:

C2uu = max(0,max(45,49.5,54.45)-45) = 9.45

C2ud = max(0,max(45,49.5,47.025)-45) = 4.5

C2du = max(0,max(45,42.75,47.025)-45) = 2.025

C2dd = max(0,max(45,42.75,40.6125)-45) = 0

At time t=1 the prices are:

C1u = (0.37*9.45 + (1-0.37)*4.5)/(1+0.005) = 6.28

C1d = (0.37*2.025 + (1-0.37)*0)/(1+0.005) = 0.74

At time t=0 the call price is then:

C0 = (0.37*6.28 + (1-0.37)*0.74)/(1+0.005) = 2.76

iii. Consider alternatively a look-back call option with a *floating strike price*. The strike price is determined at maturity and it is equal to the stock market price at maturity. The pay-off of this option is equal to the maximum between 0 and D, where D is the difference between the stock price at maturity and the *lowest* stock price during the life of the option. Calculate the price of this option.

The price of the look-back option with a floating strike can be obtained using the risk-neutral probabilities as follows:

At time t=2 the prices are:
C2uu = max(0,54.45 – min(45,49.5,54.45)) = 9.45
C2ud = max(0,47.025 – min(45,49.5,47.025)) = 2.025
C2du = max(0,47.025 – min(45,42.75,47.025)) = 4.275
C2dd = max(0,40.6125 – min(45,42.75,40.6125)) = 0

At time t=1 the prices are:
C1u = (0.37*9.45 + (1-0.37)*2.025)/(1+0.005) = 4.72
C1d = (0.37*4.275 + (1-0.37)*0)/(1+0.005) = 1.56

At time t=0 the call price is then:
C0 = (0.37*4.72 + (1-0.37)*1.56)/(1+0.005) = 2.7

iv. Comment on the difference (if any) between the prices of the look-back option with a fixed strike price and the look-back option with a floating strike price.

**Part c. (2 points)**

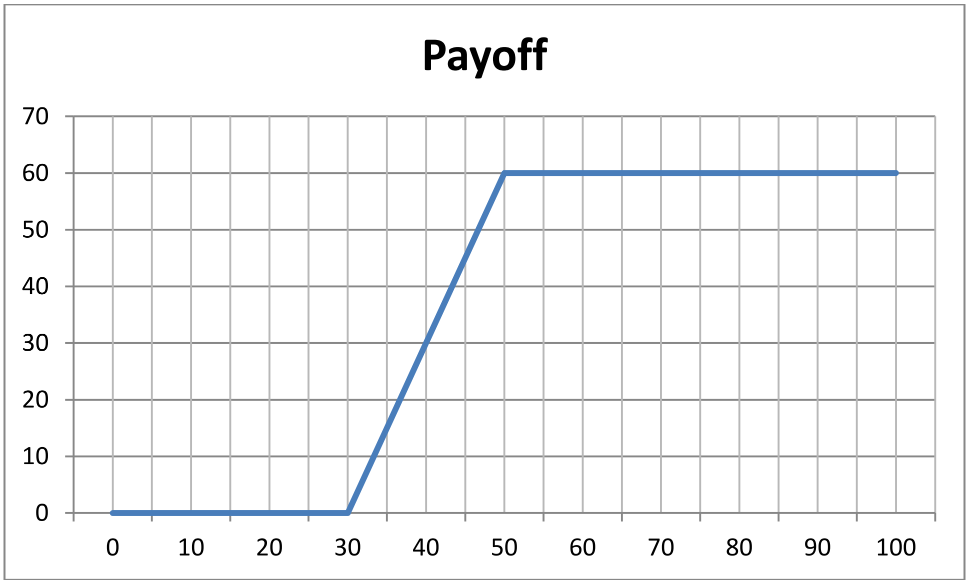
State the put-call parity relationship. Does it hold for the case of the look-back option with a fixed strike price?

C – P = S – PV(X)

It does not hold because the underlying is the maximum stock price during the life of the option which cannot be bought directly on the market.

**Part d. (4 points)**

Replicate the payoff of the collar, given below. Use (i) only put options and a cash account, or (ii) only call options and a cash account. (horizontal axis has the price of the underlying stock, vertical axis the payoff of the collar at maturity)




3 long call @ 30, 3 short call @ 50

Lend PV(60), 3 short put @ 50, 3 long put @ 30