J.K. SHAH®
CLASSES
CAFC→INTER CA→FINAL CA↗

FINAL CA
MAY '19
REVISION NOTES
Strategic Financial Management

Derivatives :
Futures & Options

DERIVATIVES : FUTURES & OPTIONS

SECTION 1 : FUTURES

Definition

A futures contract is a legal agreement, generally made on the trading floor of a futures exchange, to buy or sell a particular commodity or financial instrument at a predetermined price at a specified time in the future.

Common types of futures:

Some of the most common types of futures traded across the globe are:

a. Stock Futures
b. Index Futures
c. Commodity Futures
d. Currency Futures.

Advantages and Disadvantages of Futures

Advantages

a. It allows hedgers to shift risks to speculators.
b. It gives traders an efficient idea of what the futures price of a stock or value of an index is likely to be.
c. Based on the current future price, it helps in determining the future demand and supply of the shares.
d. Since it is based on margin trading, it allows small speculators to participate and trade in the futures market by paying a small margin instead of the entire value of physical holdings.

Disadvantages

However, one must be aware of the risks involved too.

a. The main risk stems from the temptation to speculate excessively due to a high leverage factor, which could amplify losses in the same way as it multiplies profits.
b. Further, as derivative products are slightly more complicated than stocks or tracking an index, lack of knowledge among market participants could lead to losses.
c. Since these are exchange traded products - they have standard lot sizes and expiry dates. This might pose a problem for matching the risk exposures in terms of quantity (or value) and time

Pricing of Futures

The most commonly used model for pricing of futures is known as the "Cost of Carry model". According to cost of carry model the price of Futures = Spot price + Net Cost of Carry. The formula can be modified slightly by expanding the term Net cost of carry as Cost of Carry - Carrying return.

In other words :

Future = Spot + (Cost of carry - Carrying return)

Carry Cost refers to the cost of holding the asset till the futures contract matures. This could include storage cost, interest paid to acquire and hold the asset, financing costs etc.

Carry Return refers to any income derived from the asset while holding it like dividends, bonuses etc. While calculating the futures price of an index, the Carry Return refers to the average returns given by the index during the holding period in the cash market. A net of these two is called the net cost of carry.

Mathematically the basic pricing model can be expressed as follows :

$$Futures = Spot\ (1+r)^n$$

However, this basic model undergoes slight modification depending on the type of futures being calculate e.g stock futures, index futures or commodity futures. This modification is required to factor in storage costs (typically in case of commodities) and dividend returns (in case of stocks / index).

Hence we can state as under:

Commodity futures:

Futures = (Spot + Present Value of Storage) $(1+r)^n$

Stock futures:

Futures = (Spot - Present Value of Dividends) $(1+r)^n$

Index futures

Futures = Spot $[1+(r-d)]^n$

What is continuous compounding

Continuous compounding is the mathematical limit that compound interest can reach. It is an extreme case of compounding since most interest is compounded on a monthly, quarterly or semiannual basis. Hypothetically, with continuous compounding, interest is calculated and added to the account's balance every infinitesimally small instant. While this is not possible in practice, the concept of continuously compounded interest is important in finance and is very frequently used in valuation of derivatives.

Continuous compounding can be expressed as:

Amount = Principal x e^{rn}

Where e = 2.7183 (constant); r = continuously compounded rate of interest (CCRI) and n = time

If futures price is to be computed using a continuously compounded rate then the models can be expressed as under:

Stock futures :

Futures = (Spot - PV of Dividend) x e^{rn}

Commodity futures :

Futures = (Spot + PV of Storage) x e^{rn}

Index futures:

Futures = Spot x $e^{(r-d)n}$

Margins

Since futures are exchange traded products, they are subject to initial margins and mark to market margins (MTM margins).

Initial Margin : This is the margin required to be paid at the initiation of the trade. Normally it is at 10% of the trade value. Both the buyer as well as seller are required to pay the initial margins.

Mark to Market Margin (MTM Margin): Every day the trade in futures is marked to market and the resultant profit or loss is debited or credited to the clients account. This process is known as marking to market and the resultant debits or credits are called as Mark to Market margins.

Top up Margin : If the balance in the margin account goes below the maintenance levels (i.e the level which if breached would trigger the margin call) the client is required to bring in additional margins of such amount as is required to bring the balance in margin account back to the initial margin levels.

DISTINCTION BETWEEN FUTURES AND FORWARDS:

Parameter	Forwards	Futures
Nature	A telephonic contract	An exchange traded product
Standardisation	Individually tailor made for every customer and therefore has no standard size	Since they are exchange traded - size (lots) are standardised.
Settlement	Normally settled by actual delivery	Cash settled - rarely settled by delivery
Settlement	Settlement takes place between two parties directly	Since they are exchange traded, settlement takes place through clearing houses
Transaction cost	Cost of forward contract is based on bid- ask spread	Entails brokerage fees
Marking to market	No marking to market	Marked to market on a daily basis
Margins	No Margins required	Initial Margins to be put up at the time of executing the trade
Credit risk	Subject to counter party risks	No counter party risks since transaction happens through an exchange and broker

SECTION 2 : OPTIONS

What are options?

In finance, an option is a contract which gives the buyer (the owner or holder of the option) the right, but not the obligation, to buy or sell an underlying asset or instrument at a specific strike price on a specified date, depending on the form of the option.

The seller has the corresponding obligation to fulfil the transaction—to sell or buy—if the buyer (owner) "exercises" the option.

An option that conveys to the owner the right to buy at a specific price is referred to as a call; an option that conveys the right of the owner to sell at a specific price is referred to as a put.

DEFINITION OF VARIOUS TERMS USED IN OPTIONS

Call option	Gives the buyer the right but not the obligation to buy the underlying security at a specific price for a specified time. The seller of the call option (writer) has the obligation to sell the underlying asset if the buyer exercises his options
Put option	Gives the buyer the right but not the obligation to sell the underlying security at a specific price for a specified time. The seller of the call option (writer) has the obligation to buy the underlying asset if the buyer exercises his options
Option premium	Premium is the price at which the contract trades. The premium is the price of the option and is paid by the buyer of the option to writer or seller of the option. The writer gains the premium irrespective of whether the option is exercised or not.
Strike Price /Exercise price	It is the specified price at which the underlying asset is to be bought or sold by the buyer if he exercises his option
Contract Size	The number of shares of the underlying asset covered by the options contract.
Open Interest	Number of outstanding contract options in the exchange market. In the futures market it refers to the number of long or short positions undertaken but not squared off.
American option	An option which can be exercised at any time between the date of purchase and the expiration date.
European option	An option which can be exercised only on the expiration date.
Expiration Date	The last day (in case of American option) or the only day in case of European option on which the option can be exercised. In India this date is the last Thursday (or previous business day if Thursday is a holiday) of the expiration month

At the money, In the money & Out of the money

In the money

If by exercising the option the buyer makes a profit then the option is in the money

At the money

If by exercising the option the buyer neither makes a profit nor a loss then the option is at the money

Out of money

If by exercising the option the buyer makes a loss then the option is out of the money

Option premium and its constituents

Option premium consists of two components: Intrinsic value + Time value

Intrinsic value

- Intrinsic value is that part of option premium which represents the extent to which the option is in the money.
- The balance is the time value of money.
- An option which is out of money or at the money has zero intrinsic value.
- Intrinsic value can never be negative.

Time Value

a. Also called as the extrinsic value of option
b. Represents the probability of the change in the underlying price that determines the value of the option during the remaining time till expiration.
c. This value depends on the time to expiration and the volatility of the underlying.
d. If an option is at the money or out of money the entire premium represents the time value.
e. Time value can also be never negative.
f. All options will have time value right upto the date they expire.
g. However as this time is constantly eroding, the time value of option declines over the balance period.
h. That is why options are referred to as wasting assets.
i. The decay begins slowly but starts accelerating towards the end causing the option to quickly lose value. This is because the market makers decide that it is unlikely that the underlying will gain value.

Table showing Intrinsic Value

If the option is	Does it have Intrinsic Value	Does it have Time Value
IN THE MONEY	YES	YES
AT THE MONEY	NO	YES
OUT OF MONEY	NO	YES

Option spreads

Option spreads means taking position in two or more options of the same type (calls or puts) on the same underlying.

Vertical spread [Price spread]

- Two legs have different strike price but the same expiration date.
- E.g. Buying a December Call with a strike price of Rs.100 and sell a December Call on the same script with a strike price of Rs.110.

Horizontal spread [Time spread]

- Two legs having the same strike price but different expiration date.
- E.g. Buying a December call option for Rs.100 and selling a January Call option Rs.100

Diagonal spread [Price & Time Spread]

- Two legs having different strike prices and different expiration dates.
- E.g. Buying a December call option for Rs.100 and selling a December Call for Rs.110

Other option strategies

Bull Put / Call Spread & Bear Put / Call Spread

Bull Call / Put spread	*Bear Call put spread*
Purchase and sale of put / call at different strike price	Purchase and sale of put / call at different strike price
Same Expiry date	Same Expiry date
Purchased put/ call to have a lower strike price than the sold put / call	Purchased put/ call to have a higher strike price than the sold put / call
Example Purchase a Dec call at Rs.100 and sell a Dec Call at Rs.110; [Bull Call Spread] or Purchase a Dec put at Rs.35 and sell a Dec put at Rs.37 [Bull Put Spread]	Example: Purchase a Dec call at Rs.100 and sell a Dec Call at Rs.90 [Bear Call Spread] Purchase a Dec put at Rs.35 and sell a Dec put at 33 [Bear Put Spread]

Straddle and Strangle

This strategy is adopted where the direction of the market is not known but the volatility is there in the underlying.

Long straddle: purchasing a call and put option with the same exercise price.

Short straddle: selling a call and put option with the same exercise price is a short straddle.

Long strangle: Purchasing a call and put option with different strike price

Short strangle: Selling a call and put option with different strike price

Put Call Parity theorem

A portfolio comprising a call option and an amount of cash equal to present value of option's strike price has the same expiration value as a portfolio comprising a corresponding put option and the underlying.

If the expiration values of the two portfolios are the same then their present value must also be the same. This is called put call parity.

If two portfolios are going to have the same expiration value then they must have the same value today. If this is not the case then the investor can make an arbitrage profits.
Put call parity is not based on any option pricing model. It has been derived purely using arbitrage arguments

Let us make the following terminology for building a model:
Sp = Spot price today
P = Price of Put
C = Price of call
X = Strike Price
St = Market price on the strike day

Using the above Put Call parity theorem can be expressed as :

Put + Stock = Call + Investment in Present Value of Strike Price ; i.e
P + S = C + PV(X)

Option Pricing Models

There are 3 main models which can be used for pricing options :
1) Binomial Riskless Model
2) Binomial Risk Neutral Model
3) Black Scholes Model

Binomial Riskless Model

Binomial option pricing is a simple but powerful technique that can be used to solve many complex option-pricing problems. In contrast to the Black-Scholes and other complex option-pricing models that require solutions to stochastic differential equations, the binomial option-pricing model (two- state option-pricing model) is mathematically simple. It is based on the assumption of no arbitrage.
The assumption of no arbitrage implies that all risk-free investments earn the risk-free rate of return and no investment opportunities exist that require zero amount of investment but yield positive returns.

A model which ensures that the expiration values of any portfolio is the same irrespective of any price.
Let us make the following assumptions:
i) CMP of stock = Rs. 100
ii) Possible moves = Rs.110 or Rs.90
iii) Strike price of call option = Rs.100
iv) Price of Call = "C"
v) rate of interest = 6% CCRI
vi) Time to expiry = 1 month

Our final objective is to find out the value of "C" i.e the option price

Step I	Create a portfolio buying "h" number of shares at the CMP of Rs.100. Current value of portfolio = Rs.100h
Step 2	Protect the above portfolio by selling a call at a price "C". Now the value of the portfolio will be ▪.100 h - C
THE IMPACT OF TWO POSSIBLE MOVES ARE ANALYSED BELOW	

If stock price goes to ₹.110	If stock price goes to ₹ 90
Portfolio Value = ₹ 110h - C; or ₹ 110h - ₹ 10 [Since Call would have a value of ₹ 10]	Portfolio Value = ₹ 90h - C; or ₹ 90h -₹ 0 [Since Call would have a value of ₹ 0]

Step 3	Since the values must be equal in a risk less model we can state that: ₹ 110h - ₹ 10 = ₹ 90h - ₹ 0 Solving the above we get h = 0.5
Step 4	Substituting the value of h in ₹ 110 h - ₹ 10 or alternatively substituting the value of h in ₹ 90h - ₹ 0 we get the portfolio value on expiry as ₹ 45
Step 5	If the Value of portfolio on expiry is ₹ 45, then the value of portfolio today must be equal to the Present Value of ₹ 45 which is ₹ 45 x e^{-rt} where r = 6% CCRI and t = 1/12
Step 6	But we know that the value of portfolio today is ₹ 100 h - C [refer step 2]
Step 7	Hence we can say that ▪ 100h - C = ▪ 45 x e^{-rt} Solving the equation given that h = 0.5, e = 2.7183, r = 6% CCRI and t = 1/12 we get the value of C = Rs 5.22

Binomial Risk Neutral model

In the risk less hedge approach, the probability of the stock price increasing, Pu, or the probability of the stock price decreasing, Pd = 1-Pu, did not enter into the analysis at all. In the risk neutral approach, given a stock price process (tree) we try to estimate these probabilities for a risk neutral individual and then use these risk neutral probabilities to price a call option.

In the above example for the Riskless model, the model ignored the probability of the prices hitting the level of Rs.110 or Rs.90. The risk neutral valuation approach takes into consideration the probability of a stock price moving up or down and factors the same in calculating the price of an option.

Example explaining the concept

Let P_u be the probability of price going up; then the probability of price going down i.e $P_d = 1 - P_u$
Let us make the following assumption:

i. CMP = Rs.75
ii. Upward possible price = Rs.95
iii. Downward possible price = Rs.63
iv. Call option strike price = Rs.65 (one month)
v. Risk free rate = 6%

We know that : CMP of Stock = Present Value of Future expected values
i.e CMP = PV of [(upward price x p_u) + (downward price x p_d)]
i.e CMP = PV of [(upward price x p_u) + (downward price x $(1-p_u)$]
Hence Rs.75 today = PV of expected values
Now,
Expected values = P_u (95) + P_d(63); or
$P_{(u)}(95) + (1-P_u)(63)$

PV of expected values = $[P_{(u)}(95) + (1-P_u)(63)]*e^{-rt}$
i.e Rs.75 = $[P_{(u)}(95) + (1-P_u)(63)]*e^{-rt}$
Solving the above equation for r =6% and T= 1 month we get the values of P_u and P_d
P_u = 0.38675 and P_d = (1-0.38675) i.e. 0.61325

Now we calculate the expected value of Call

If price of stock on expiry	Value of Call with strike price = ▪ 65	Probability	Expected value
95	30	0.38675	11.6025
63	0	0.61325	0
Expected value of call on expiry			11.6025
Hence value of call today = Present value of 11.6025 @ 6% per annum for 1 month : ₹ 11.6025 x e^{-rt}			₹ 11.54

Black Scholes Model

a) First propogated in 1973 by Fischer Black and Myron Scholes.
b) It has become the standard for valuing options
c) Predominantly used for calculating European Options
d) It utilizes the stock price, strike price, expiration date, risk free return, and the standard deviation (volatility) of the stock's return.

The formula for Black Scholes model is:
$C = S.N.(d_1) – Xe^{-rt}.N(d_2)$
Where
C = Value of Option
S = Spot price
X = Strike price
R = risk free interest rate
T = time till expiration
N = area under normal curve
$D_1 = [(\text{Log } s/x) + (r + {}^2/2)T\ ]\ T^{1/2}$
$D_2 = D1 - T^{1/2}$

Valuing Real Options

Real Options Valuation, also often termed real options analysis,(ROV or ROA) applies option valuation techniques to capital budgeting decisions.A real option itself, is the right — but not the obligation — to undertake certain business initiatives, such as deferring, abandoning, expanding, staging, or contracting a capital investment project. For example, the opportunity to invest in the expansion of a firm's factory, or alternatively to sell the factory, is a real call or put option, respectively.
Real options are generally distinguished from conventional financial options in that they are not typically traded as securities, and do not usually involve decisions on an underlying asset that is traded as a financial security. A further distinction is that option holders here, i.e. management, can directly influence

the value of the option's underlying project; whereas this is not a consideration as regards the underlying security of a financial option. Moreover, management cannot lookup for a volatility as uncertainty, instead their perceived uncertainty matters in real options reasoning's. Unlike financial options, management also have to create or discover real options, and such creation and discovery process comprises an entrepreneurial or business task. Real options are most valuable when uncertainty is high; management has significant flexibility to change the course of the project in a favorable direction and is willing to exercise the options.

Option Greeks

Gamma

Gamma is a measure of rate of change of delta for small changes in underlying stock price - in other words it is delta of the delta. While using delta to hedge the portfolio we need to keep in mind that we should keep the gamma very low . If gamma is very high then a small change in the underlying would result in delta going haywire and therefore your hedge might collapse.

Theta

Theta measures the change in option price if the period to maturity reduces by one day. In simple words it is a measure of time decay. Now we know that time decay of an option is inevitable and bound to take place. So there is no point in hedging for the same.

All options – both Calls and Puts lose value as the expiration approaches. The Theta or time decay factor is the rate at which an option loses value as time passes. Theta is expressed in points lost per day when all other conditions remain the same. Time runs in one direction, hence theta is always a positive number, however to remind traders it's a loss in options value it is sometimes written as a negative number. A Theta of -0.5 indicates that the option premium will lose -0.5 points for every day that passes by. For example, if an option is trading at Rs.2.75/- with theta of -0.05 then it will trade at Rs.2.70/- the following day (provided other things are kept constant). A long option (option buyer) will always have a negative theta meaning all else equal, the option buyer will lose money on a day by day basis. A short option (option seller) will have a positive theta. Theta is a friendly Greek to the option seller. Remember the objective of the option seller is to retain the premium. Given that options loses value on a daily basis, the option seller can benefit by retaining the premium to the extent it loses value owing to time. For example if an option writer has sold options at Rs.54, with theta of 0.75, all else equal, the same option is likely to trade at – =0.75 * 3 = 2.25 = 54 – 2.25 = 51.75 Hence the seller can choose to close the option position on T+ 3 day by buying it back at Rs.51.75/- and profiting Rs.2.25 …

Rho

Rho measures the change in option price given a one percentage change in risk free interest rate. In other words it measures how sensitive the option value is to change in interest rates. For example a Rho of 0.05 indicates that the options theoretical value will increase by 0.05 if interest rate is decreased by 1

Vega

Vega indicates the change in value of option for one percentage change in volatility. The option's vega is a measure of the impact of changes in the underlying volatility on the option price. Specifically, the vega of an option expresses the change in the price of the option for every 1% change in underlying volatility.

Example of Vega

A stock XYZ is trading at ▪ 46 in May and a JUN 50 call is selling for ▪ 2. Let's assume that the vega of the option is 0.15 and that the underlying volatility is 25%.
If the underlying volatility increased by 1% to 26%, then the price of the option should rise to ▪ 2 + 0.15 = ▪ 2.15.
However, if the volatility had gone down by 2% to 23% instead, then the option price should drop to ▪ 2 - (2 x 0.15) = $1.70

SECTION A : FUTURES

Q.1 Spot price of Infosys is ₹ 2000. Interest rate prevailing is 14% per annum. Expected dividend after 2 months is ₹ 10 per share. Calculate what should be the expected price of Infosys today in the 3 months futures markets.

Q.2 For X Ltd, spot rate = ₹ 70, continuous compounded rate of interest is 8%. Calculate price of future with 3 months expiry if the stock pays a dividend of ₹ 1.5 on expiry [e0.02 = 1.02020].

Q.3 Stock index currently stands at ₹ 3500. The risk free interest rate is 8% per annum & the dividend yield on the index is 4% per annum. Calculate the 4 month index future if the of 8% is CCRI [e0.0133 = 1.014].

Q.4 The current price of cotton is ₹ 400 per bale. The storage cost is ₹ 100 per bale per year payable in arrears. Assuming that interest rates are 10% per annum [CCRI], calculate the one year future price per bale of cotton [e0.10 = 1.1051].

Q.5 On 31-7-2017 the value of stock index is 2600. The risk free return is 9% per annum. The dividend yield on this stock index is as follows :

Month	Dividend yield
January	2%
February	5%
March	2%
April	2%
May	5%
June	2%
July	2%
August	5%
September	2%
October	2%
November	5%
December	2%

Assuming that interest is continuously compounded, what will be the future price of contract deliverable on 31-12-2011. Given e0.02417 = 1.02446 or say 1.0245

Q.6 The following data relates to ABC Ltd's share prices

Current price per share = ₹ 180

Price per share in the futures markets - 6 months = ₹ 195

It is possible to borrow money in the market for securities transaction at the rate of 12% per annum.

Required:

a. Calculate the theoretical minimum price of 6 months futures.

b. Explain if any arbitrage opportunities exist.

Margins on Futures

Q.7 On November 15, when the spot price for TELCO is ₹ 473 per share, Mr X buys 15 contracts of July TELCO futures at ₹ 491. Assume that the initial margin for TELCO futures is ₹ 800 per contract, and the maintenance margin is ₹ 600 per contract. Given that each contract is 50 shares. Daily settlement prices for the next few days are as follows :

Nov 15th	₹ 496
Nov 16th	₹ 503
Nov 17th	₹ 488
Nov 18th	₹ 485
Nov 19th	₹ 491

Assume that Mr X withdraws profits from his margin account only once on Nov 16th when he withdraws half the maximum amount allowed. Compute the balance in the account at the end of each of these days. Find his profit or loss at the end of Nov 19th.

Futures & Hedging

Q.8 Ram buys 10000 shares of X Ltd at ₹ 22 and obtains a complete hedge of shorting 400 Nifties at ₹ 1100 each. He closes out his position at the closing price of the next day at which point the share price of X Ltd has dropped 2% and the Nifty futures has dropped 1.5%. What is the overall profit / loss on this set of transaction.

Q.9

BSE Index	5000
Value of Portfolio	₹. 10,10,000
Risk free interest rate	9% per annum
Dividend yield on Index	6% per annum
Beta of portfolio	1.5

We assume that a futures contract on the BSE index with 4 months maturity is used to hedge the value of portfolio over next 3 months. One future contract is for delivery of 50 times the index. Based on the above information, calculate:

a. Price of future contract.

b. The gain on short position of futures if index turns out to be 4500 in 3 months

Q.10 A company is long on 10 MT of copper at ₹ 474 per kg (spot) and intends to remain so for the ensuing quarter. The standard deviation of change of its spot and future prices are 4% and 6% respectively, having a co-relation co-efficent of 0.75. What is the hedge ratio? What is the amount of the copper futures it should short to achieve a perfect hedge.

Q.11 A High Networth Individual (HNI) is holding the following portfolio is Rupees crores:

Investment in diversified equity shares	80.00
Cash and Bank Balance	20.00
Total	100.00

The Beta of the portfolio is 0.8. The index futures is selling at 5500 levels. The HNI wants to increase the beta of the portfolio for he believes tha the market would up from the current level. How many index futures he should buy / sell so that the beta is increased to 1.20. One index futures consists of 100 units.

Q.12 On April 1, 2015 an investor has a portfolio consisting of eight securities as shown below:
The cost of capital for the investor is 20% per annum continuously compounded. The investor fears a fall in the prices of the shares in the near future. Accordingly he approaches you for the advice to protect the interest of his portfolio. You can make use of the following information:

a. The current NIFTY value is 8500

b. NIFTY futures can be traded in units of 25 only.

c. Futures for May are currently quoted at 8,700 and futures for June are being quoted at 8850.

You are required to calculate :

i. The beta of his portfolio.

ii. The theoretical value of the futures contracts expiring in May and June

iii. Given that e0.03 = 1.03045, e0.04 = 1.04081, e0.05 = 1.05127

iv. The number of NIFTY contracts that he would have to sell if desires to hedge until June in each of the following cases:

a. His total portfolio

b. 50% of his portfolio

c. 120% of his portfolio

Security	Market Price	No of shares	Beta value
A	29.40	400	0.59
B	318.70	800	1.32
C	660.20	150	0.87
D	5.20	300	0.35
E	281.90	400	1.16
F	275.40	750	1.24
G	514.60	300	1.05
H	170.50	900	0.76

SECTION B : OPTIONS

ITM / ATM / OTM / Time value & Intrinsic Value

Q.13 Given the following data determine the value of the call option at their expiration dates:

Option	Market price per share on Expiry	Exercise price of the option
A	10	12
B	25	21
C	48	52
D	7	5

Q.14 State whether each one of the following is In the Money (ITM), At the Money (ATM) or Out of Money (OTM)

Option	Exercise price	Spot
Call	60	55
Call	50	50
Call	110	105
Call	40	35
Put	110	100
Put	105	115
Put	12	15
Put	25	20

Q.15 A stock with a current market price of ₹ 50 has the following exercise price and call option premium. Compute the intrinsic value and time value:

Exercise price	45	48	50	52	55
Premium	9	6	4	3	2

Q.16 A stock with a current market price of ₹ 50 has the following exercise price and put option premium. Compute the intrinsic value and time value:

Exercise price	45	48	50	52	55
Premium	1	2	3	5	7

Pay off tables / Spreads / Strategies

Q.17 The equity shares of Ramacast Ltd are being sold at ₹ 210. A 3 month call option is available for a premium of ₹ 6 per share and a 3 month Put is available for a premium of ₹ 5 per share. Find out the net pay off of the option holder of the call option and put option given that (i) the strike price in both the case is ₹ 220, and (ii) the share price on expiry is ₹200 or ₹ 210 or₹220 or ₹ 230 or ₹ 240

Q.18 Equity shares of Casio Ltd are being currently sold for ₹ 90 per share. Both the call option and the put option for 3 month period are available for a strike price of ₹ 97 at a premium of ₹ 3 and ₹ 2 respectively. Prepare the payoff table if price of share on expiry ranges between 80 to ₹ 120 in ticks of ₹ 10 if an creates a (i) Strip or (ii) Strap

Q.19 A trader buys for ₹ 3 a call with a strike price of ₹ 30 and sells for ₹ 1 a call with a strike price of ₹ 35. Calculate his net pay off if the stock price at the end of expiration period is:

a. Less than or equal to ₹ 30
b. More than or equal to ₹ 35
c. About ₹ 30 but below ₹ 35

Q.20 A trader buys for ₹ 1 a call with a strike price of ▪ 35 and sells for ▪ 3 a call with a strike price of ₹ 30. Calculate his net pay off if the stock price at the end of expiration period is:

a. Less than or equal to ₹ 30
b. More than or equal to ₹ 35
c. About ₹ 30 but below ₹ 35

Q.21 Suppose that a certain stock is currently worth ₹ 61. A trader feels that a significant price move in the next 6 months is unlikely. The market price of 6 month calls are as follows:

Strike Price (₹)	Call Price (₹)
55	10
60	7
65	5

Create a Butterfly spread for the investor and show the payoff of the overall strategy presuming that price of share on expiry could range between ₹ 30 to ₹ 80 in ticks of ₹ .5

Put Call Parity / Arbitrage

Q.22 You are given the following information about ABC Ltd's share and call option:

Current share price	₹ 90
Option Strike Price	₹ 110
Risk free interest rate	10%
Time to option expiry	1 year
Call Premium	12
Put Premium	21

You are required to analyses if there is any arbitrage opportunity

Q.23 You are given the following information about ABC Ltd's share and call option:

Current share price	₹ 90
Option Strike Price	₹ 110
Risk free interest rate	10%
Time to option expiry	1 year
Call Premium	12
Put Premium	24

You are required to analyses if there is any arbitrage opportunity

Option valuation: Binomial / Black Scholes

Q.24 Consider a two year American call option with a strike price of ₹ 50 on a stock the current price of which is also ₹ 50. Assume that there are two time periods of one year and in each year the stock price can move up or down by equal percentage of 20%. The risk free interest rate is 6%. Using Binomial risk neutral model calculate the value of call and probability of price moving up and down. Also draw a two-step binomial tree showing prices and payoffs at each.

Q.25 An equity share is currently selling for Rs. 80. In a year's time. It can rise by 30 percent or fall by 15 percent. The exercise price of a call option on this share is Rs.90.
What is the value of the call option if the risk-free rate is 8 percent? Use the Binomial Method risk less model

Q.26 X Ltd's share is currently trading at ₹ 220. It is expected that in 6 months' time it could double or halve. One year call option on X Ltd' share has an exercise price of ₹ 165. Assuming the risk free rate of interest to be 20% calculate:

(a) value of call option of X Ltd's share.

(b) Option delta for the second 6 month in case the stock price rises to ₹ 440 or falls to ₹ 110

(c) Now suppose in 6 months the share price is ₹ 110. How at this point can we replicate portfolio of call options and risk free lending.

Q.27 (i) The shares of TIC Ltd are currently priced at ₹ 415 and call option exercisable in three months' time has an exercise rate of ₹ 400. Risk free interest rate is 5% p.a (CCRI) and standard deviation of share price is 22%. Based on the assumption that TIC is not going to declare any dividend over the next 3 months is the option worth buying at ₹ 25.

(ii) Calculate the aforesaid call option based on Black Scholes Model if the current market price of share is ₹ 380

(iii) What would be the worth of Put option if the current price is considered ₹ 380.

(iv) If TIC share price at present is taken at ₹ 408 and a dividend of ₹ 10 is expected to be paid in 2 months' time then calculate the value of call option.

Q.28 From the following data for a certain stock, find the value of call option:

Price of stock now	=	₹ 80
Exercise price	=	₹ 75
Standard Deviation	=	0.40
Maturity period	=	6 months
Annual Interest rate	=	12% CCRI

Given :

No of S.D from mean (z)	Area of the left or right (one tail)
0.25	0.4013
0.30	0.3821
0.55	0.2912
0.60	0.2578

$e^{0.06} = 1.060$ and Ln 1.0667 = 0.0645

Q.29 You are trying to value a long term call option on the Standard and Poor 500, expiring in 2 months with a strike price of $ 900. The index is currently at $ 930 and the annualized standard deviation in stock prices is 20% per annum. The average dividend yield on the index is 0.3% per month, and expected to remain unchanged over the next month. The treasury bond rate is 8%.

a. Estimate the value of the long term call option.

b. Estimate the value of a put option with the same parameters.

Q.30 IPL is already in Production of Fertiliser and is considering a proposal of building a new plant to produce pesticides. Suppose the Present value of proposal is ₹ 100 crores without the abandonment option. However, if market conditions for pesticide turns out to be favourable the PV of the proposal shall increase by 30%. On the other hand if the market conditions remain sluggish the PV of the proposal shall be reduced by 40%. In case company is not interested in continuation of the project it can be disposed off for ₹ 80 crores. If the risk free rate of interest is 8% then what will be the value of abandonment option.

Q.31 ABC Ltd is a pharmaceutical company possessing a patent of a drug called "Aidrex" a medicine for aids patients. Being an approach drug ABC Ltd holds the right of production of drugs and its marketing. The period of the patent is 15 year after which any other pharmaceutical company can produce the drug with the same formula. It is estimated that company shall required to incur $ 12.5 million for development and marketing of the drug. As per survey conducted the present value of expected cash flow from the sale of drug during 15 years shall be $ 16.70 million. Cash flow from the previous similar type of drug have exhibited a variance of 26.8% of the present value of cash flows. The current yield on Treasury Bonds of similar duration (15 years) is 7.8%. Determine the value of the patent.

Arbitrage between Futures and Options

Q.41 You are given the following information about ABC's futures and options:

March futures price = ₹ 123

Details of March options are as under:

Strike Price = ₹ 150

Call Premium = ₹ 20

Put Premium = ₹ 50

Explain if any arbitrage opportunity exists

Q.42 You are given the following information about ABC's futures and options:

March futures price = ₹ 122

Details of March options are as under:

Strike Price = ₹ 130

Call Premium = ₹ 8

Put Premium = ₹ 10

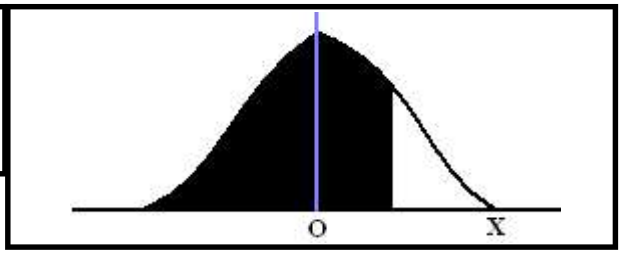
Explain if any arbitrage opportunity exists

TABLE : AREAS UNDER THE STANDARD NORMAL CURVE FROM 0 TO Z.

Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
.4	.1554	.1591	.1628	1664	.1700	.1736	.1772	.1808	.1844	.1879
.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
.7	.2580	.2612	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133
.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4252	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	4772	.4778	.4783	.4788	.4793	.4798	.4803	4808	.4812	.4817
2.1	.4821	4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	4861	4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4931	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.49865	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990
4.0	.4999683									

Illustration: For Z = 1.72, shaded area is .4573 out of total area of 1.

AREAS UNDER THE STANDARD NORMAL CURVE from - ∞ to x



x	0	1	2	3	4	5	6	7	8	9
0.0	.5000	.5040	5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
0.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5754
0.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
0.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
0.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
0.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
0.6	.7258	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7518	.7549
0.7	.7580	.7910	.7939	.7967	.7996	.8023	.8051	.8078	.8106	.8133
0.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9987	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990
3.1	.9990	.9991	.9991	.9991	.9992	.9992	.9992	.9992	.9993	.9993
3.2	.9993	.9993	.9994	.9994	.9994	.9994	.9994	.9995	.9995	.9995
3.3	.9995	.9995	.9995	.9996	.9996	.9996	.9996	.9996	.9996	.9997
3.4	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9998
3.5	.9998	.9998	.9998	.9998	.9998	.9998	.9998	.9998	.9998	.9998
3.6	.9998	.9998	.9999	.9999	.9999	.9999	.9999	.9999	.9999	.9999
3.7	.9999	.9999	.9999	.9999	.9999	.9999	.9999	.9999	.9999	.9999
3.8	.9999	.9999	.9999	.9999	.9999	.9999	.9999	.9999	.9999	.9999
3.9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

LOGARITHMS

	0	1	2	3	4	5	6	7	8	9	Mean Differences								
											1	2	3	4	5	6	7	8	9
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	4	8	12	17	21	25	29	33	37
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	4	8	11	15	19	23	26	30	34
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106	3	7	10	14	17	21	24	28	31
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	3	6	10	13	16	19	23	26	29
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	3	6	9	12	15	18	21	24	27
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	3	6	8	11	14	17	20	22	25
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	3	5	8	11	13	16	18	21	24
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	2	5	7	10	12	15	17	20	22
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	2	5	7	9	12	14	16	19	21
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	2	4	7	9	11	13	16	18	20
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	2	4	6	8	11	13	15	17	19
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	2	4	6	8	10	12	14	16	18
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	2	4	6	8	10	12	14	15	17
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	2	4	6	7	9	11	13	15	17
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	2	4	5	7	9	11	12	14	16
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	2	3	5	7	9	10	12	14	15
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	2	3	5	7	8	10	11	13	15
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	2	3	5	6	8	9	11	13	14
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	2	3	5	6	8	9	11	12	14
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	1	3	4	6	7	9	10	12	13
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	1	3	4	6	7	9	10	11	13
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	1	3	4	6	7	8	10	11	12
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	1	3	4	5	7	8	9	11	12
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	1	3	4	5	6	8	9	10	12
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	1	3	4	5	6	8	9	10	11
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	1	2	4	5	6	7	9	10	11
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	1	2	4	5	6	7	8	10	11
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	1	2	3	5	6	7	8	9	10
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	1	2	3	5	6	7	8	9	10
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	1	2	3	4	5	7	8	9	10
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	1	2	3	4	5	6	8	9	10
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	1	2	3	4	5	6	7	8	9
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	1	2	3	4	5	6	7	8	9
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	1	2	3	4	5	6	7	8	9
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	1	2	3	4	5	6	7	8	9
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	1	2	3	4	5	6	7	8	9
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	1	2	3	4	5	6	7	7	8
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	1	2	3	4	5	5	6	7	8
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893	1	2	3	4	4	5	6	7	8
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	1	2	3	4	4	5	6	7	8
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	1	2	3	3	4	5	6	7	8
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	1	2	3	3	4	5	6	7	8
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	1	2	2	3	4	5	6	7	7
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	1	2	2	3	4	5	6	6	7
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	1	2	2	3	4	5	6	6	7

LOGARITHMS

	0	1	2	3	4	5	6	7	8	9	Mean Differences								
											1	2	3	4	5	6	7	8	9
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	1	2	2	3	4	5	5	6	7
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551	1	2	2	3	4	5	5	6	7
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	1	2	2	3	4	5	5	6	7
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	1	1	2	3	4	4	5	6	7
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	1	1	2	3	4	4	5	6	7
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846	1	1	2	3	4	4	5	6	6
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917	1	1	2	3	4	4	5	6	6
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	1	1	2	3	3	4	5	6	6
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	1	1	2	3	3	4	5	5	6
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	1	1	2	3	3	4	5	5	6
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	1	1	2	3	3	4	5	5	6
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	1	1	2	3	3	4	5	5	6
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	1	1	2	3	3	4	5	5	6
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	1	1	2	3	3	4	4	5	6
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	1	1	2	2	3	4	4	5	6
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506	1	1	2	2	3	4	4	5	6
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	1	1	2	2	3	4	4	5	5
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	1	1	2	2	3	4	4	5	5
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	1	1	2	2	3	4	4	5	5
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	1	1	2	2	3	4	4	5	5
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	1	1	2	2	3	3	4	5	5
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	1	1	2	2	3	3	4	5	5
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	1	1	2	2	3	3	4	4	5
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	1	1	2	2	3	3	4	4	5
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	1	1	2	2	3	3	4	4	5
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	1	1	2	2	3	3	4	4	5
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	1	1	2	2	3	3	4	4	5
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	1	1	2	2	3	3	4	4	5
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	1	1	2	2	3	3	4	4	5
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	1	1	2	2	3	3	4	4	5
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	1	1	2	2	3	3	4	4	5
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	1	1	2	2	3	3	4	4	5
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440	0	1	1	2	2	3	3	4	4
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	0	1	1	2	2	3	3	4	4
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538	0	1	1	2	2	3	3	4	4
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	0	1	1	2	2	3	3	4	4
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	0	1	1	2	2	3	3	4	4
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	0	1	1	2	2	3	3	4	4
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	0	1	1	2	2	3	3	4	4
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	0	1	1	2	2	3	3	4	4
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	0	1	1	2	2	3	3	4	4
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	0	1	1	2	2	3	3	4	4
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	0	1	1	2	2	3	3	4	4
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952	0	1	1	2	2	3	3	4	4
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996	0	1	1	2	2	3	3	3	4

ANTILOGARITHMS

Degrees	0	1	2	3	4	5	6	7	8	9	Mean Differences								
											1	2	3	4	5	6	7	8	9
.00	1000	1002	1005	1007	1009	1012	1014	1016	1019	1021	0	0	1	1	1	1	2	2	2
.01	1023	1026	1028	1030	1033	1035	1038	1040	1042	1045	0	0	1	1	1	1	2	2	2
.02	1047	1050	1052	1054	1057	1059	1062	1064	1067	1069	0	0	1	1	1	1	2	2	2
.03	1072	1074	1076	1079	1081	1084	1086	1089	1091	1094	0	0	1	1	1	1	2	2	2
.04	1096	1099	1102	1104	1107	1109	1112	1114	1117	1119	0	1	1	1	1	2	2	2	2
.05	1122	1125	1127	1130	1132	1135	1138	1140	1143	1146	0	1	1	1	1	2	2	2	2
.06	1148	1151	1153	1156	1159	1161	1164	1167	1169	1172	0	1	1	1	1	2	2	2	2
.07	1175	1178	1180	1183	1186	1189	1191	1194	1197	1199	0	1	1	1	1	2	2	2	2
.08	1202	1205	1208	1211	1213	1216	1219	1222	1225	1227	0	1	1	1	1	2	2	2	3
.09	1230	1233	1236	1239	1242	1245	1247	1250	1253	1256	0	1	1	1	1	2	2	2	3
.10	1259	1262	1265	1268	1271	1274	1276	1279	1282	1285	0	1	1	1	1	2	2	2	3
.11	1288	1291	1294	1297	1300	1303	1306	1309	1312	1315	0	1	1	1	2	2	2	2	3
.12	1318	1321	1324	1327	1330	1334	1337	1340	1343	1346	0	1	1	1	2	2	2	2	3
.13	1349	1352	1355	1358	1361	1365	1368	1371	1374	1377	0	1	1	1	2	2	2	3	3
.14	1380	1384	1387	1390	1393	1396	1400	1403	1406	1409	0	1	1	1	2	2	2	3	3
.15	1413	1416	1419	1422	1426	1429	1432	1435	1439	1442	0	1	1	1	2	2	2	3	3
.16	1445	1449	1452	1455	1459	1462	1466	1469	1472	1476	0	1	1	1	2	2	2	3	3
.17	1479	1483	1486	1489	1493	1496	1500	1503	1507	1510	0	1	1	1	2	2	2	3	3
.18	1514	1517	1521	1524	1528	1531	1535	1538	1542	1545	0	1	1	1	2	2	2	3	3
.19	1549	1552	1556	1560	1563	1567	1570	1574	1578	1581	0	1	1	1	2	2	3	3	3
.20	1585	1589	1592	1596	1600	1603	1607	1611	1614	1618	0	1	1	1	2	2	3	3	3
.21	1622	1626	1629	1633	1637	1641	1644	1648	1652	1656	0	1	1	2	2	2	3	3	3
.22	1660	1663	1667	1671	1675	1679	1683	1687	1690	1694	0	1	1	2	2	2	3	3	3
.23	1698	1702	1706	1710	1714	1718	1722	1726	1730	1734	0	1	1	2	2	2	3	3	4
.24	1738	1742	1746	1750	1754	1758	1762	1766	1770	1774	0	1	1	2	2	2	3	3	4
.25	1778	1782	1786	1791	1795	1799	1803	1807	1811	1816	0	1	1	2	2	2	3	3	4
.26	1820	1824	1828	1832	1837	1841	1845	1849	1854	1858	0	1	1	2	2	3	3	3	4
.27	1862	1866	1871	1875	1879	1884	1888	1892	1897	1901	0	1	1	2	2	3	3	3	4
.28	1905	1910	1914	1919	1923	1928	1932	1936	1941	1945	0	1	1	2	2	3	3	4	4
.29	1950	1954	1959	1963	1968	1972	1977	1982	1986	1991	0	1	1	2	2	3	3	4	4
.30	1995	2000	2004	2009	2014	2018	2023	2028	2032	2037	0	1	1	2	2	3	3	4	4
.31	2042	2046	2051	2056	2061	2065	2070	2075	2080	2084	0	1	1	2	2	3	3	4	4
.32	2089	2094	2099	2104	2109	2113	2118	2123	2128	2133	0	1	1	2	2	3	3	4	4
.33	2138	2143	2148	2153	2158	2163	2168	2173	2178	2183	0	1	1	2	2	3	3	4	4
.34	2188	2193	2198	2203	2208	2213	2218	2223	2228	2234	1	1	2	2	3	3	4	4	5
.35	2239	2244	2249	2254	2259	2265	2270	2275	2280	2286	1	1	2	2	3	3	4	4	5
.36	2291	2296	2301	2307	2312	2317	2323	2328	2333	2339	1	1	2	2	3	3	4	4	5
.37	2344	2350	2355	2360	2366	2371	2377	2382	2388	2393	1	1	2	2	3	3	4	4	5
.38	2399	2404	2410	2415	2421	2427	2432	2438	2443	2449	1	1	2	2	3	3	4	4	5
.39	2455	2460	2466	2472	2477	2483	2489	2495	2500	2506	1	1	2	2	3	3	4	5	5
.40	2512	2518	2523	2529	2535	2541	2547	2553	2559	2564	1	1	2	2	3	4	4	5	5
.41	2570	2576	2582	2588	2594	2600	2606	2612	2618	2624	1	1	2	2	3	4	4	5	5
.42	2630	2636	2642	2649	2655	2661	2667	2673	2679	2685	1	1	2	2	3	4	4	5	6
.43	2692	2698	2704	2710	2716	2723	2729	2735	2742	2748	1	1	2	3	3	4	4	5	6
.44	2754	2761	2767	2773	2780	2786	2793	2799	2805	2812	1	1	2	3	3	4	4	5	6
.45	2818	2825	2831	2838	2844	2851	2858	2864	2871	2877	1	1	2	3	3	4	5	5	6
.46	2884	2891	2897	2904	2911	2917	2924	2931	2938	2944	1	1	2	3	3	4	5	5	6
.47	2951	2958	2965	2972	2979	2985	2992	2999	3006	3013	1	1	2	3	3	4	5	5	6
.48	3020	3027	3034	3041	3048	3055	3062	3069	3076	3083	1	1	2	3	4	4	5	6	6
.49	3090	3097	3105	3112	3119	3126	3133	3141	3148	3155	1	1	2	3	4	4	5	6	6

ANTILOGARITHMS

Degress	0	1	2	3	4	5	6	7	8	9	Mean Differences								
											1	2	3	4	5	6	7	8	9
.50	3162	3170	3177	3184	3192	3199	3206	3214	3221	3228	1	1	2	3	4	4	5	6	7
.51	3236	3243	3251	3258	3266	3273	3281	3289	3296	3304	1	2	2	3	4	5	5	6	7
.52	3311	3319	3327	3334	3342	3350	3357	3365	3373	3381	1	2	2	3	4	5	5	6	7
.53	3388	3396	3404	3412	3420	3428	3436	3443	3451	3459	1	2	2	3	4	5	6	6	7
.54	3467	3475	3483	3491	3499	3508	3516	3524	3532	3540	1	2	2	3	4	5	6	6	7
.55	3548	3556	3565	3573	3581	3589	3597	3606	3614	3622	1	2	2	3	4	5	6	7	7
.56	3631	3639	3648	3656	3664	3673	3681	3690	3698	3707	1	2	3	3	4	5	6	7	8
.57	3715	3724	3733	3741	3750	3758	3767	3776	3784	3793	1	2	3	3	4	5	6	7	8
.58	3802	3811	3819	3828	3837	3846	3855	3864	3873	3882	1	2	3	4	4	5	6	7	8
.59	3890	3899	3908	3917	3926	3936	3945	3954	3963	3972	1	2	3	4	5	5	6	7	8
.60	3981	3990	3999	4009	4018	4027	4036	4046	4055	4064	1	2	3	4	5	6	6	7	8
.61	4074	4083	4093	4102	4111	4121	4130	4140	4150	4159	1	2	3	4	5	6	7	8	9
.62	4169	4178	4188	4198	4207	4217	4227	4236	4246	4256	1	2	3	4	5	6	7	8	9
.63	4266	4276	4285	4295	4305	4315	4325	4335	4345	4355	1	2	3	4	5	6	7	8	9
.64	4365	4375	4385	4395	4406	4416	4426	4436	4446	4457	1	2	3	4	5	6	7	8	9
.65	4467	4477	4487	4498	4508	4519	4529	4539	4550	4560	1	2	3	4	5	6	7	8	9
.66	4571	4581	4592	4603	4613	4624	4634	4645	4656	4667	1	2	3	4	5	6	7	9	10
.67	4677	4688	4699	4710	4721	4732	4742	4753	4764	4775	1	2	3	4	5	7	8	9	10
.68	4786	4797	4808	4819	4831	4842	4853	4864	4875	4887	1	2	3	4	6	7	8	9	10
.69	4898	4909	4920	4932	4943	4955	4966	4977	4989	5000	1	2	3	5	6	7	8	9	10
.70	5012	5023	5035	5047	5058	5070	5082	5093	5105	5117	1	2	4	5	6	7	8	9	11
.71	5129	5140	5152	5164	5176	5188	5200	5212	5224	5236	1	2	4	5	6	7	8	10	11
.72	5248	5260	5272	5284	5297	5309	5321	5333	5346	5358	1	2	4	5	6	7	9	10	11
.73	5370	5383	5395	5408	5420	5433	5445	5458	5470	5483	1	3	4	5	6	8	9	10	11
.74	5495	5508	5521	5534	5546	5559	5572	5585	5598	5610	1	3	4	5	6	8	9	10	12
.75	5623	5636	5649	5662	5675	5689	5702	5715	5728	5741	1	3	4	5	7	8	9	10	12
.76	5754	5768	5781	5794	5808	5821	5834	5848	5861	5875	1	3	4	5	7	8	9	11	12
.77	5888	5902	5916	5929	5943	5957	5970	5984	5998	6012	1	3	4	5	7	8	10	11	12
.78	6026	6039	6053	6067	6081	6095	6109	6124	6138	6152	1	3	4	6	7	8	10	11	13
.79	6166	6180	6194	6209	6223	6237	6252	6266	6281	6295	1	3	4	6	7	9	10	11	13
.80	6310	6324	6339	6353	6368	6383	6397	6412	6427	6442	1	3	4	6	7	9	10	12	13
.81	6457	6471	6486	6501	6516	6531	6546	6561	6577	6592	2	3	5	6	8	9	11	12	14
.82	6607	6622	6637	6653	6668	6683	6699	6714	6730	6745	2	3	5	6	8	9	11	12	14
.83	6761	6776	6792	6808	6823	6839	6855	6871	6887	6902	2	3	5	6	8	9	11	13	14
.84	6918	6934	6950	6966	6982	6998	7015	7031	7047	7063	2	3	5	6	8	10	11	13	15
.85	7079	7096	7112	7129	7145	7161	7178	7194	7211	7228	2	3	5	7	8	10	12	13	15
.86	7244	7261	7278	7295	7311	7328	7345	7362	7379	7396	2	3	5	7	8	10	12	13	15
.87	7413	7430	7447	7464	7482	7499	7516	7534	7551	7568	2	3	5	7	9	10	12	14	16
.88	7586	7603	7621	7638	7656	7674	7691	7709	7727	7745	2	4	5	7	9	11	12	14	16
.89	7762	7780	7798	7816	7834	7852	7870	7889	7907	7925	2	4	5	7	9	11	13	14	16
.90	7943	7962	7980	7998	8017	8035	8054	8072	8091	8110	2	4	6	7	9	11	13	15	17
.91	8128	8147	8166	8185	8204	8222	8241	8260	8279	8299	2	4	6	8	9	11	13	15	17
.92	8318	8337	8356	8375	8395	8414	8433	8453	8472	8492	2	4	6	8	10	12	14	15	17
.93	8511	8531	8551	8570	8590	8610	8630	8650	8670	8690	2	4	6	8	10	12	14	16	18
.94	8710	8730	8750	8770	8790	8810	8831	8851	8872	8892	2	4	6	8	10	12	14	16	18
.95	8913	8933	8954	8974	8995	9016	9036	9057	9078	9099	2	4	6	8	10	12	15	17	19
.96	9120	9141	9162	9183	9204	9226	9247	9268	9290	9311	2	4	6	8	11	13	15	17	19
.97	9333	9354	9376	9397	9419	9441	9462	9484	9506	9528	2	4	7	9	11	13	15	17	20
.98	9550	9572	9594	9616	9638	9661	9683	9705	9727	9750	2	4	7	9	11	13	16	18	20
.99	9772	9795	9817	9840	9863	9886	9908	9931	9954	9977	2	5	7	9	11	14	16	18	20