



## DIPLOMA SUMMER 2009 EXAMINATION

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### FINANCIAL DERIVATIVES

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<b>DATE OF EXAM</b>	Thursday 25 June 2009
<b>3 HOURS</b>	2.00 pm – 5.00 pm
<b>RUBRIC</b>	SECTION A - <i>ALL</i> questions in this section are to be answered
	SECTION B } Answer <b>FOUR</b> questions in total from Sections B and C, at least <b>TWO</b> questions from Section B and <b>ONE</b> from SECTION C } Section C. The remaining question may be from <b>EITHER</b> Section.

**Candidates are reminded that no marks will be awarded for illegible work**

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#### NOTES TO CANDIDATES

1. Please insert your Candidate Number on the cover of your Answer Book. *Do not insert your name.*
2. Show *all* workings in your Answer Book.
3. Candidates may attempt the sections in any order. Please indicate clearly in your Answer Book which questions you are answering.
4. Please insert in the box provided on the cover of your Answer Book the numbers of the questions you have attempted in the order in which they appear in the Answer Book.
5. You may use the calculator provided or one approved by the Securities & Investment Institute.
6. You must hand your Answer Book to an invigilator before you leave the Examination Hall. *Failure to do so will result in disqualification.*
7. Once submitted, the examination scripts become the property of the Securities & Investment Institute and will not be returned to candidates.

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**PLEASE TURN OVER WHEN INSTRUCTED**

**Answer ALL questions in this section**

- 1 The current date is December 18, 2009. You observe the LIFFE March 2010 short sterling futures contract trading at 98.09/98.10. The last trading day is March 18, 2010. Determine the upper and lower arbitrage bounds on the futures price if the current cash market interest rates are:

3-MONTH 1.40% / 1.50%

6-MONTH 1.90% / 2.00%

(4 marks)

- 2 You observe on 27/4/09 that the US Treasury 7.5% 15/11/24 Bond for settlement on 30/4/09 is trading at 143-29 and the September 2009 Treasury Bond future is trading at 122-28. If the conversion or price factor for the Bond is 1.1470, the implied Repo rate is 0.32% and the actual Repo rate is 0.20%, estimate the gross and net basis for the Bond in 32nds.

(4 marks)

- 3 You have entered into a £50 million forward FX contract to sell dollars for sterling at a rate of \$1.50/£ in three months time. The current three month forward rate is \$1.55/£. If the forward FX rate volatility is 10%, estimate the Value at Risk (VAR) for your position over a two week time horizon at a 95% one-sided confidence interval.

(4 marks)

- 4 You observe the following discount function for Euros:

6-MONTH 0.991967

12-MONTH 0.983939

18-MONTH 0.974556

24-MONTH 0.963065

30-MONTH 0.949881

36-MONTH 0.935235

Determine the fair fixed rate on a receive fixed, pay floating two year swap commencing in one year's time. On the swap you will receive on an annual basis and pay on a six-monthly basis.

(4 marks)

- 5 Analyse the following statements concerning the continuous yield version of the Black-Scholes model for index options and its assumptions.

a) The sensitivity of a call option price to a specific change in the index yield will be less than the sensitivity to an equal change in the interest rate. (2 marks)

b) The drift assumed for the index value in estimating a forward value is not the same as that assumed in valuing an option. (2 marks)

## SECTION B

Answer **FOUR** questions in total from Sections B and C, **TWO** questions from Section B and **ONE** from Section C. The remaining question may be from **EITHER** Section. All questions in these sections carry **20** marks.

- 6 You own the following portfolio of US Treasury Bonds all of which are deliverable against the September 2009 US Treasury Bond futures contract. The current date is 2/6/09. The actual REPO rate is 0.45% for each bond.

<u>MATURITY</u>	<u>COUPON</u>	<u>DURATION</u>	<u>BASIS POINT VALUE</u>	<u>ACCRUED INTEREST</u>	<u>CONVERSION FACTOR (SEPTEMBER)</u>	<u>PRICE</u>	<u>IMPLIED REPO</u>	<u>AMOUNT</u>
15/11/24	7.50	10.435	0.15105	2.258287	1.1470	145-05+	0.53%	75,000,000
15/11/27	6.125	12.160	1.15700	1.844268	1.0142	129-24+	-1.00%	100,000,000
15/2/31	5.375	13.965	0.16619	0.252417	0.9254	121-03	-5.60%	75,000,000

You observe that money market rates are flat at 0.50%, the September Treasury Bond future is trading at 123-06, and the December Treasury Bond future is trading at 121-12+. Assume the 7.5% 15/11/24 Bond is the Cheapest to Deliver for both contracts.

- a) Determine the appropriate futures hedge for a July 24th 2009 maturity date that will minimise the basis risk. Explain in detail all the steps in your hedge calculation. *(8 marks)*
- b) What value of the bond portfolio do you believe you are locking in? *(4 marks)*
- c) You observe the following market prices on 24/7/09

US SEPTEMBER FUTURES PRICE            122-28

US DECEMBER FUTURES PRICE            121-26

<u>MATURITY</u>	<u>COUPON</u>	<u>PRICE</u>	<u>ACCRUED INTEREST</u>	<u>IMPLIED REPO</u>	<u>ACTUAL REPO</u>
15/11/24	7.50	143-30	3.314917	0.33%	0.20%
15/11/27	6.125	128-09	2.707182	-2.00%	0.20%
15/2/31	5.375	120-02+	1.009669	-7.80%	0.20%

Analyse the result of your hedge, and discuss any hedge inefficiencies that have occurred. *(8 marks)*

- 7 Give a brief assessment of the following statements concerning derivatives and derivatives markets.
- a) The use of risk-free interest rates in pricing individual equity put options is incorrect given the costs of stock borrowing. (6 marks)
  - b) Most models for pricing interest rate derivatives and Foreign Exchange spot and forward rate derivatives are inconsistent. (8 marks)
  - c) Careful assessment of local volatilities is essential for the pricing of barrier options. (6 marks)

8 You observe the following discount function and interest rates for sterling:

	<u>PAR RATE</u>	<u>ZERO RATE</u>	<u>DISCOUNT FACTOR</u>
12-MONTH	1.5000	1.5000	0.985222
24-MONTH	1.7500	1.7522	0.965856
36-MONTH	2.0000	2.0067	0.942136

You have the following anticipated cash flows:

IN 15-MONTHS TIME	+£10,000,000
IN 30-MONTHS TIME	-£12,000,000

- a) Calculate the current present value of your book assuming linear interpolation of the zero interest rates. (4 marks)
  - b) Estimate the book's equivalent cash flows at 12, 24 and 36 months. (6 marks)
  - c) Show how the risks of those equivalent cash flows can be eliminated by appropriate positions in par swaps. (6 marks)
  - d) Comment on any residual interest rate risks that remain. (4 marks)
- 9 You are provided with market information on UK FTSE-100 index option and volatilities on the Bloomberg screens shown on pages 8 and 9 of this question paper.
- a) Explain the P/L and risk characteristics of a position that is short a 4150 strike May straddle and long a June 4000/4300 strangle. (4 marks)

b) You own the following portfolio of options:

<u>BUY/SELL</u>	<u>OPTION TYPE</u>	<u>POSITION</u>	<u>STRIKE</u>	<u>MATURITY</u>
BUY	PUT	100	4100	MAY
SELL	CALL	75	4250	MAY
SELL	PUT	75	4050	MAY
BUY	CALL	75	4150	JUNE
BUY	PUT	100	4150	JUNE

Estimate the sterling change in the value of the overall position, explaining your results, if the FTSE -100 index moves to 4350 and volatility falls 2.5% over a two week period. (8 marks)

c) For the May options in the portfolio in b) establish the level of the FTSE-100 at maturity index where the overall position would breakeven. (4 marks)

d) Comment on the pattern of implied volatilities you observe for the May and June FTSE-100 options. (4 marks)

10 An investment bank is asked by a customer to quote on a capital guaranteed product, which will provide at the end of five years his money back plus a proportion of the performance of the Standard and Poors 500 index or gold, whichever is the higher. Assume the bank would wish to earn a margin of 25 basis points per annum on the product. The following market information is available:

	<u>1Y</u>	<u>2Y</u>	<u>3Y</u>	<u>4Y</u>	<u>5Y</u>
US INTEREST RATES	4.00%	4.50%	5.00%	5.50%	6.00%
S+P 500 VOLATILITY	25%	23%	21%	20%	19%
GOLD VOLATILITY	16%	14%	12%	11%	10%
GOLD FORWARD PRICE	103.00%	107.12%	112.49%	121.55%	127.62%
GOLD / S+P500 CORRELATION	0.30	0.32	0.37	0.40	0.45

The dividend yield on the S+P 500 index can be assumed to be flat at 2% per annum. Interest rates and dividend yields are provided as continuously compounded rates.

a) Determine the proportion of the performance of the better performing of the two markets that could be promised to the customer. (14 marks)

b) Discuss the issues involved in structuring and hedging this product from the point of view of the investment bank. (6 marks)

11 You are provided with the following information for the UK equity market:

EQUITY INDEX LEVEL = 4000

INDEX VOLATILITY = 25% PER ANNUM

EQUITY INDEX YIELD = 2% (CONTINUOUSLY COMPOUNDED)

(Assume interest rates in the UK are flat at 4% (continuously compounded).)

- a) Estimate the price of a 5% in the money American put option using a three step binomial model. *(6 marks)*
  
- b) Demonstrate the results of a delta hedge of the put option if the market falls in the first period, rises in the second period, and falls again in the third period. *(10 marks)*
  
- c) Explain the risks of such delta hedging strategies in practice. *(4 marks)*

## SECTION C

**All questions carry 20 marks.**

- 12 Discuss the valuation approaches you are aware of for Credit Default Swaps and Basket Credit Default Swaps, and analyse how deficiencies in the model assumptions may have become apparent in the credit crisis of 2008-09.
- 13 You observe that the Regulatory Authorities have become much more focussed on Stress Testing than Value at Risk and other standard risk assessment techniques to determine the adequacy of financial institutions' capital. Discuss the reasons for and implications of this for the future of derivatives trading.
- 14 You are a major multinational agricultural conglomerate used to running large derivatives positions, both trading and hedging, in many soft commodities such as grains, coffee and cocoa, sugar, soya beans, juices etc. Your chief executive has suggested that an involvement in weather derivatives would be a natural fit for the firm's existing activities, and has asked you to produce a short report on the issues involved. Prepare such a report for your CEO.
- 15 One result of the credit crunch of 2008-09 has been a major effort to set up a centrally cleared exchange type system for all types of credit derivatives. Discuss how such a system could work and what the implications would have been if it had been in place from 2007, and in the future.

Bloomberg screens for question 9:

<HELP> for explanation. Index **COAT**  
 Screen Printed to Page [1 of 2]  
**CALL OPTION ANALYSIS** Hit 99 <go> to change option model defaults  
 May 09 Calls on UKX

UNDERLYING **UKX** PRICE **4156.0** +137.8 Time 16:35 BID .00 ASK .00 VOLUME 1,272,567 PREV 4018.2  
 Using discounted future price 4147.7  
 19 days left at 0.76% Finance Rate from 4/26/09 to 5/15/09 Expiration

Strikes	Market		User		Hedge	TIME	7-Day	I.VOL	CHANGE		
	PRICE	I.VOL	Price	Volat					DEL	GAM	VALUE
1) 3950	219.0	29.45%	219.0	29.45%	748	0011	21.3	10.8	3.0	+6.67%	-17.2%
2) 3975	211.5	32.67%	211.5	32.67%	701	0011	38.8	15.2	3.3	+6.23%	-10.9%
3) 4000	193.5	32.25%	193.5	32.25%	673	0012	45.8	16.2	3.4	+6.02%	-9.65%
4) 4025	176.5	31.92%	176.5	31.92%	644	0012	53.8	17.2	3.5	+5.85%	-8.65%
5) 4050	160.0	31.52%	160.0	31.52%	613	0013	62.3	18.0	3.6	+5.71%	-7.84%
6) 4075	144.0	31.06%	144.0	31.06%	581	0013	71.3	18.5	3.7	+5.61%	-7.15%
7) 4100	129.5	30.78%	129.5	30.78%	548	0013	81.8	19.0	3.7	+5.54%	-6.54%
8) 4125	115.5	30.42%	115.5	30.42%	513	0014	92.8	19.3	3.8	+5.50%	-6.01%
9) 4150	102.0	29.96%	102.0	29.96%	478	0014	102.0	19.2	3.8	+5.50%	-5.55%
10) 4200	79.5	29.54%	79.5	29.54%	408	0014	79.5	18.9	3.7	+5.61%	-4.78%
11) 4250	59.0	28.70%	59.0	28.70%	337	0013	59.0	17.3	3.5	+5.89%	-4.15%
12) 4300	43.5	28.29%	43.5	28.29%	272	0012	43.5	15.5	3.2	+6.35%	-3.65%
13) 4350	31.5	28.02%	31.5	28.02%	214	0011	31.5	13.2	2.8	+7.01%	-3.25%

Australia 61 2 9777 8600 Brazil 5511 3048 4500 Europe 44 20 7330 7500 Germany 49 69 9204 1210 Hong Kong 852 2977 6000  
 Japan 81 3 3201 8900 Singapore 65 6212 1000 U.S. 1 212 318 2000 Copyright 2009 Bloomberg Finance L.P.  
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<HELP> for explanation. Index **POAT**  
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**PUT OPTION ANALYSIS** Hit 99 <go> to change option model defaults  
 May 09 Puts on UKX

UNDERLYING **UKX** PRICE **4156.0** +137.8 Time 16:35 BID .00 ASK .00 VOLUME 1,272,567 PREV 4018.2  
 Using discounted future price 4147.6  
 19 days left at 0.76% Finance Rate from 4/26/09 to 5/15/09 Expiration

Strikes	Market		User		Hedge	TIME	7-Day	I.VOL	CHANGE		
	PRICE	I.VOL	Price	Volat					DEL	GAM	VALUE
1) 3950	52.0	32.57%	52.0	32.57%	265	0011	52.0	21.4	3.1	+6.49%	+3.45%
2) 3975	57.5	31.90%	57.5	31.90%	290	0011	57.5	22.2	3.3	+6.25%	+3.60%
3) 4000	65.0	31.66%	65.0	31.66%	319	0012	65.0	23.4	3.4	+6.04%	+3.79%
4) 4025	72.5	31.21%	72.5	31.21%	349	0012	72.5	24.3	3.5	+5.86%	+3.98%
5) 4050	81.0	30.84%	81.0	30.84%	380	0013	81.0	25.1	3.6	+5.72%	+4.20%
6) 4075	90.0	30.39%	90.0	30.39%	413	0013	90.0	25.7	3.7	+5.61%	+4.44%
7) 4100	100.5	30.13%	100.5	30.13%	447	0014	100.5	26.2	3.7	+5.54%	+4.71%
8) 4125	111.5	29.77%	111.5	29.77%	482	0014	111.5	26.5	3.8	+5.50%	+5.01%
9) 4150	123.0	29.31%	123.0	29.31%	518	0014	120.6	26.4	3.8	+5.50%	+5.34%
10) 4200	150.5	28.88%	150.5	28.88%	589	0014	98.1	26.0	3.7	+5.62%	+6.11%
11) 4250	180.0	27.99%	180.0	27.99%	662	0014	77.6	24.4	3.5	+5.92%	+7.09%
12) 4300	214.5	27.52%	214.5	27.52%	729	0013	62.1	22.5	3.1	+6.41%	+8.28%
13) 4350	252.5	27.13%	252.5	27.13%	789	0011	50.1	20.1	2.7	+7.12%	+9.71%

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Bloomberg screens for question 9 (continued):

<HELP> for explanation. Index **COAT**  
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**CALL OPTION ANALYSIS** Hit 99 <go> to change option model defaults  
 May 09 Calls on UKX

UNDERLYING **UKX** PRICE **4156.0** +137.8 Time 16:35 BID .00 ASK .00 VOLUME 1,272,567 PREV 4018.2  
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	PRICE	I.VOL	Price	Volat					DEL	GAM	VALUE
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2) 3975	211.5	32.71%	211.5	32.71%	700	0011	38.9	15.2	3.3	+6.22%	-10.8%
3) 4000	193.5	32.28%	193.5	32.28%	673	0012	45.9	16.2	3.4	+6.02%	-9.63%
4) 4025	176.5	31.95%	176.5	31.95%	643	0012	53.9	17.2	3.5	+5.85%	-8.64%
5) 4050	160.0	31.55%	160.0	31.55%	613	0013	62.4	18.0	3.6	+5.71%	-7.83%
6) 4075	144.0	31.09%	144.0	31.09%	581	0013	71.4	18.5	3.7	+5.61%	-7.14%
7) 4100	129.5	30.81%	129.5	30.81%	547	0013	81.9	19.1	3.7	+5.54%	-6.53%
8) 4125	115.5	30.44%	115.5	30.44%	513	0014	92.9	19.3	3.8	+5.50%	-6.01%
9) 4150	102.0	29.98%	102.0	29.98%	478	0014	102.0	19.3	3.8	+5.50%	-5.55%
10) 4200	79.5	29.56%	79.5	29.56%	408	0014	79.5	18.9	3.7	+5.61%	-4.78%
11) 4250	59.0	28.71%	59.0	28.71%	337	0013	59.0	17.4	3.5	+5.89%	-4.15%
12) 4300	43.5	28.31%	43.5	28.31%	272	0012	43.5	15.5	3.2	+6.35%	-3.65%
13) 4350	31.5	28.03%	31.5	28.03%	214	0011	31.5	13.2	2.8	+7.01%	-3.25%

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<HELP> for explanation. Index **POAT**  
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**PUT OPTION ANALYSIS** Hit 99 <go> to change option model defaults  
 May 09 Puts on UKX

UNDERLYING **UKX** PRICE **4156.0** +137.8 Time 16:35 BID .00 ASK .00 VOLUME 1,272,567 PREV 4018.2  
 Using discounted future price 4147.7  
 19 days left at 0.76% Finance Rate from 4/26/09 to 5/15/09 Expiration

Strikes	Market		User		Hedge	TIME	7-Day	I.VOL	CHANGE		
	PRICE	I.VOL	Price	Volat					DEL	GAM	VALUE
1) 3950	52.0	32.58%	52.0	32.58%	265	0011	52.0	21.4	3.1	+6.49%	+3.45%
2) 3975	57.5	31.92%	57.5	31.92%	290	0011	57.5	22.3	3.3	+6.26%	+3.60%
3) 4000	65.0	31.68%	65.0	31.68%	319	0012	65.0	23.4	3.4	+6.04%	+3.79%
4) 4025	72.5	31.23%	72.5	31.23%	349	0012	72.5	24.3	3.5	+5.86%	+3.98%
5) 4050	81.0	30.86%	81.0	30.86%	380	0013	81.0	25.1	3.6	+5.72%	+4.20%
6) 4075	90.0	30.41%	90.0	30.41%	412	0013	90.0	25.7	3.7	+5.61%	+4.44%
7) 4100	100.5	30.15%	100.5	30.15%	447	0014	100.5	26.2	3.7	+5.54%	+4.71%
8) 4125	111.5	29.79%	111.5	29.79%	481	0014	111.5	26.5	3.8	+5.50%	+5.01%
9) 4150	123.0	29.33%	123.0	29.33%	517	0014	120.7	26.5	3.8	+5.50%	+5.34%
10) 4200	150.5	28.90%	150.5	28.90%	589	0014	98.2	26.1	3.7	+5.62%	+6.11%
11) 4250	180.0	28.02%	180.0	28.02%	661	0014	77.7	24.5	3.5	+5.91%	+7.08%
12) 4300	214.5	27.56%	214.5	27.56%	728	0012	62.2	22.5	3.1	+6.40%	+8.27%
13) 4350	252.5	27.19%	252.5	27.19%	788	0011	50.2	20.1	2.7	+7.11%	+9.69%

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**TABLE FOR  $N(x)$  when  $x \leq 0$**

This table shows values of  $N(x)$  for  $x \leq 0$ . The table should be used with interpolation. For example

$$\begin{aligned} N(-0.1234) &= N(-0.12) - 0.34[N(-0.12) - N(-0.13)] \\ &= 0.4522 - 0.34 \times (0.4522 - 0.4483) \\ &= 0.4509 \end{aligned}$$

$x$	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
-0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641
-0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
-0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
-0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
-0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
-0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
-0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
-0.7	0.2420	0.2389	0.2358	0.2327	0.2296	0.2266	0.2236	0.2206	0.2177	0.2148
-0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
-0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
-1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
-1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
-1.2	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
-1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
-1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
-1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
-1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
-1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
-1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
-1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
-2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
-2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
-2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
-2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
-2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
-2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
-2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
-2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
-2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
-2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
-3.0	0.0014	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
-3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
-3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
-3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
-3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
-3.5	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
-3.6	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
-3.7	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
-3.8	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
-3.9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-4.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

**TABLE FOR  $N(x)$  when  $x \geq 0$**

This table shows values of  $N(x)$  for  $x \geq 0$ . The table should be used with interpolation. For example

$$\begin{aligned} N(0.6278) &= N(0.62) + 0.78[N(0.63) - N(0.62)] \\ &= 0.7324 + 0.78 \times (0.7357 - 0.7324) \\ &= 0.7350 \end{aligned}$$

$x$	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9986	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998
3.5	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998
3.6	0.9998	0.9998	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999
3.7	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999
3.8	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999
3.9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4.0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000