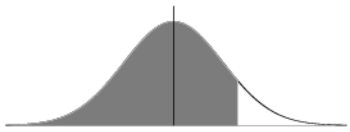
Cumulative Normal Distribution Table

$$\Phi(z) = \int_{-\infty}^{z} \frac{1}{\sqrt{2\pi}} e^{-s^2/2}\, ds$$



z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
0.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
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	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
0.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
0.8	.7881	.7910	.7939	.7967	.7995	.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

Capacity formulas

Capacity

Machine requirements for single products

$$M = \frac{Dp}{N[1-(C/100)]}$$

Machine requirements for multiple products

$$M = \frac{[Dp + (D/Q)s]_{product\ 1} + [Dp + (D/Q)s]_{product\ 2} + \cdots + [Dp + (D/Q)s]_{product\ n}}{N[1 - (C/100)]}$$

M = Number of machines

D = Yearly demand

p = processing time per product

Q = Batch size

s = setup time per batch

N = Total operating time per year

C = Desired capacity cushion (expressed in %)

Break-even analysis

Total cost $$C = F + c \times Q$$

Total revenue $$R = p \times Q$$

Break even quantity $$Q = \frac{F}{(p - c)}$$

C = Total cost

F = Fixed cost

c = variable cost

Q = Quantity of sold products/services

R = Total revenue

p = revenue per sold unit

Forecasting formulas, KPP227

Linear regression:

$$Y = a + bX$$

$$b = \frac{\Sigma XY - n\bar{X}\bar{Y}}{\Sigma x^2 - n\bar{X}^2}$$

$$a = \bar{Y} - b\bar{X}$$

Forecast accuracy (Linear regression):

Correlation coefficient: $$r = \frac{n\sum XY - \sum X \sum Y}{\sqrt{[n\sum X^2 - (\sum X)^2][n\sum Y^2 - (\sum Y)^2]}}$$

Coefficient of determination: $$r^2 = \frac{a\sum Y + b\sum XY - n\bar{Y}^2}{\sum Y^2 - n\bar{Y}^2}$$

Standard error of the estimate: $$\sigma YX = \sqrt{\frac{\sum Y^2 - a\sum Y - b\sum XY}{n-2}}$$

Weighted moving average

$$F_{t+1} = W_1 D_t + W_2 D_{t-1} + \cdots W_n D_{t-n+1}$$

Exponential smoothing

$$F_{t+1} = \alpha D_t + (1-\alpha) F_t$$

$$F_{t+1} = F_t + \alpha (D_t - F_t)$$

Exponential smoothing with trend

$$A_t = \alpha D_t + (1-\alpha)(A_{t-1} + T_{t-1})$$

$$T_1 = \beta(A_t - A_{t-1}) + (1-\beta) T_{t-1}$$

$$F_{t+1} = A_t + T_t$$

A_t =exponential smoothed average of the series in period t

T_t =exponential smoothed average of the trend in period t

α = smoothing parameter for average (value 0-1)

β = smoothing parameter for trend (value 0-1)

T_{t+1} = Forecast for period t+1

Forecast errors

Forecast error $E_t = D_t - F_t$

Average forecast error $\bar{E} = \frac{CFE}{n}$

Mean square error $MSE = \frac{\sum {E_t}^2}{n}$

Mean absolute deviation $MAD = \frac{\sum |E_t|}{n}$

Standard deviation $\sigma = \sqrt{\frac{\sum (E_t - \bar{E})^2}{n-1}}$

Mean absolute percentage error $MAPE = \frac{\sum [|E_t|(100)]/D_t}{n}$

Tracking signal $Tracking\ Signal = \frac{CFE}{MAD}$

Inventory management

Holding cost

$$Holding\ cost = \frac{Q}{2}(H)$$

Ordering-/setup cost

$$Ordering\ or\ setup\ cost = \frac{D}{Q}(S)$$

Material handling cost

$$C = \frac{Q}{2}(H) + \frac{D}{Q}(S)$$

Economic order quantity

$$EOQ = \sqrt{\frac{2DS}{H}}$$

Time between orders

$$TBO_{EOQ} = \frac{EOQ}{D}$$

Q = Order quantity

H = Holding cost per item

D = Forecasted demand

S = Setup cost per order

Continuous review (Q) system

Inventory position

$$IP = OH + SR - BO$$

IP = Inventory Point

OH = On-hand inventory

SR = Scheduled receipts

BO = Back orders

Re-order point

$$R = \bar{d}L + Safety\ stock$$

$\bar{d}$ = Average demand per time unit

L = constant lead time In time units

Standard deviation of demand during lead time: $\sigma_{dLT} = \sqrt{\sigma_d^2 L} = \sigma_d \sqrt{L}$

Safety stock: $= z\sigma_{dLT}$

Periodic review (P) system

$$T = \bar{d}(P+L) + z\sigma_{(P+L)} = \bar{d}(P+L) + z\sigma_d\sqrt{P+L}$$

T = average demand during the protection interrval + safety stock for protection interval

P = length of time between reviews

Noninstantaneous replenishment

Maximum cycle inventory: $I_{max} = \frac{Q}{p}(p-d) = Q\left(\frac{p-d}{p}\right)$

p = production rate

d = demand rate

Q = lot size

Total annual cost: $C = \frac{I_{max}}{2}(H) + \frac{D}{Q}(S)$

Total annual cost: $C = \frac{Q}{2}\left(\frac{p-d}{p}\right)(H) + \frac{D}{Q}(S)$

Economic production lot size: $ELS = \sqrt{\frac{2DS}{H}}\sqrt{\frac{p}{p-d}}$

I = Inventory
D = annual demand
p = production rate
d = demand rate
Q = lot size
H = holding cost
S = ordering/setup cost

Quantity discounts

Total annual material cost: $C = \frac{Q}{2}(H) + \frac{D}{Q}(S) + PD$

Q = lot size
H = holding cost
D = annual demand
S = ordering/setup cost
P = Price/unit
D = Demand rate

One period decisions

Payoff: $If\ Q \leq S \Rightarrow Payoff = pQ$

$If\ Q > S \Rightarrow Payoff = pD - ld$

p = profit/unit
Q = Purchased quantity
D = actual demand
l = loss/unit
d = number of disposed items

Location formulas, KPP227

Location

Load distance $$ld = \sum_i l_i d_i$$

Euclidian distance $$d_{AB} = \sqrt{(X_A - X_B)^2 + (Y_A - Y_B)^2}$$

Rectilinear distance $$d_{AB} = |X_A - X_B| + |Y_A - Y_B|$$

Center of gravity

$$X^* = \frac{\sum l_i X_i}{\sum l_i}$$

$$Y^* = \frac{\sum l_i Y_i}{\sum l_i}$$

Waiting lines formulas, KPP227

Waiting lines

Interarrival times

$$P_n = \frac{(\lambda T)^n}{n!} e^{-\lambda T} \quad \textit{for } n = 1,2,\ldots$$

P_n = Probability of n arrivals in T time periods

λ = Average numbers of cutomer arrivals per period

Service time distribution

$$P_{(t \leq T)} = 1 - e^{-\mu T}$$

μ = Average number of customers completing service per period

t = service time of the customer

T = target service time

Single server model

Average utilization of the system

$$\rho = \frac{\lambda}{\mu}$$

Average number of customers in the system

$$L = \frac{\lambda}{\mu - \lambda}$$

Average number of customers in the waiting line

$$L_q = \rho L = \frac{\lambda^2}{\mu(\mu - \lambda)}$$

Average time spent in the system including service

$$W = \frac{1}{\mu - \lambda}$$

Average waiting time in line

$$W_q = \rho W = \frac{\lambda}{\mu(\mu - \lambda)}$$

Probability that n customers are in the system

$$P_n = (1-\rho)\rho^n$$

Probability that 0 customers are in the system

$$P_0 = 1 - \frac{\lambda}{\mu}$$

Probability that less than *k* customers are in the system

$$P_{n<k} = 1 - \left(\frac{\lambda}{\mu}\right)^k$$

Probability of more than *k* customers are in the system

$$P_{n>k} = \left(\frac{\lambda}{\mu}\right)^{k+1}$$

MRP

Item:	Week:	1	2	3	4	5	6	7	8
	Due:								
	Release:								

Item:	Week:	1	2	3	4	5	6	7	8
	Due:								
	Release:								

Item:	Week:	1	2	3	4	5	6	7	8
	Due:								
	Release:								

Item: Lot size:
Lead time:
Safety stock:

	Week:	1	2	3	4	5	6	7	8
Gross requirements									
Scheduled reciepts									
Projected on hand									
Planned reciepts									
Planned order releases									

Item: Lot size:
Lead time:
Safety stock:

	Week:	1	2	3	4	5	6	7	8
Gross requirements									
Scheduled reciepts									
Projected on hand									
Planned reciepts									
Planned order releases									

Item: Lot size:
Lead time:
Safety stock:

	Week:	1	2	3	4	5	6	7	8
Gross requirements									
Scheduled reciepts									
Projected on hand									
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Planned order releases									

Item: Lot size:
Lead time:
Safety stock:

	Week:	1	2	3	4	5	6	7	8
Gross requirements									
Scheduled reciepts									
Projected on hand									
Planned reciepts									
Planned order releases									