Unit 1: Basic Probability	
1.	$Probability = P(A) = \frac{No.\, of\ possible\ outcomes}{Total\ no.\, of\ outcomes}$
2.	$Probability\ of\ an\ impossible\ event = P(\phi) = 0$
3.	$P(\bar{A}) = 1 - P(A)$ $P(A) + P(\bar{A}) = 1$ $P(A) \leq 1$
4.	$P(A \cup B) = P(A) + P(B) - P(A \cap B)$ • $If\ A\ and\ B\ are\ mutually\ exclusive\ events\ (do\ not\ occur\ simultaneously)\ then$ $P(A \cap B) = 0 \therefore P(A \cup B) = P(A) + P(B)$ • $If\ A\ and\ independent\ events\ then\ P(A \cap B) = P(A)\ P(B)$ $P(A \cup B \cup C) = P(A) + P(B) + P(C) - P(A \cap B) - P(B \cap C) - P(C \cap A) + P(A \cap B \cap C)$ • $If\ A, B\ and\ C\ are\ mutually\ exclusive\ events\ (do\ not\ occur\ simultaneously)\ then$ $P(A \cap B) = 0, P(B \cap C) = 0, P(A \cap B) = 0\ and\ P(A \cap B \cap C) = 0$ • $If\ A\ and\ independent\ events\ then\ P(A \cap B \cap C) = P(A)\ P(B)\ P(C)$ $P(\bar{A} \cap B) = P(B) - P(A \cap B)$ $P(A \cap \bar{B}) = P(A) - P(A \cap B)$ ***De Morgan's Laws***: $P(\overline{A \cap B}) = P(\bar{A} \cup \bar{B})$ $P(\overline{A \cup B}) = P(\bar{A} \cap \bar{B})$ $P(A \cup B) = 1 - P(\bar{A} \cap \bar{B})$ $P(A \cap B) = 1 - P(\bar{A} \cup \bar{B})$
5.	***Conditional Probability***: $P(A/B) = \frac{P(A \cap B)}{P(B)} \therefore P(A \cap B) = P(A/B)\ P(B)$ $P(B/A) = \frac{P(A \cap B)}{P(A)} \therefore P(A \cap B) = P(B/A)\ P(A)$
6.	***Bayes' Theorem***: $A_1, A_2, \dots A_n\ are\ mutually\ exclusive\ and\ exhaustive\ events\ and\ B\ is\ an\ event\ that\ occur$ $in\ combination\ with\ any\ one\ of\ the\ events\ A_1, A_2, \dots A_n\ then$ $P(A_i/B) = \frac{P(A_i)P(B/A_i)}{\sum_{i=1}^{n} P(A_i)P(B/A_i)}$
7.	***Properties of Probability Mass Function (One Dimensional Discrete)***: $p(x_i) \geq 0\ for\ all\ values\ of\ i$ $\sum_{i=1}^{\infty} p(x_i) = 1$

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8.	***Properties of Probability Density Function*** (***One Dimensional Continuous***): $f(x) \geq 0 \quad -\infty < x < \infty$ $\int_{-\infty}^{\infty} f(x)\,dx = 1$ $P(a < x < b) = \int_{a}^{b} f(x)\,dx$
9.	***Properties of Joint Probability Mass Function*** (***Two Dimensional Discrete***): $p_{XY}(x_i, y_j) \geq 0\ for\ all\ values\ of\ i\ and\ j$ $\sum_{j=1}^{n}\sum_{i=1}^{m} p_{XY}(x_i, y_j) = 1$ $Marginal\ Probability\ p_X(x_i) = \sum_{j=1}^{m} p(x_i, y_j)$ $Marginal\ Probability\ p_Y(y_i) = \sum_{i=1}^{n} p(x_i, y_j)$ $Conditional\ Probability\ p_{X/Y} = P(X = x/Y = y) = \frac{P(X = x, Y = y)}{P(Y = y)}$ $Conditional\ Probability\ p_{Y/X} = P(Y = y/X = x) = \frac{P(X = x, Y = y)}{P(X = x)}$ $Necessary\ and\ sufficient\ condition\ for\ X\ and\ Y\ to\ be\ independent\ is$ $P(X = x_i, Y = y_j) = P(X = x_i)P(Y = y_j)$
10.	***Properties of Joint Probability Density Function*** (***Two Dimensional Continuous***): $f(x, y) \geq 0\ for\ all\ x, y$ $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x, y)\,dx\,dy = 1$ $P(a \leq X \leq b, c \leq Y \leq d) = \int_{c}^{d}\int_{a}^{b} f(x, y)\,dx\,dy$ $Marginal\ Probability\ f_X(x) = \int_{-\infty}^{\infty} f(x, y)\,dy$ $Marginal\ Probability\ f_Y(y) = \int_{-\infty}^{\infty} f(x, y)\,dx$ $Conditional\ Probability\ f(x/y) = \frac{f(x, y)}{f_{Y(y)}}$ $Conditional\ Probability\ f(y/x) = \frac{f(x, y)}{f_{X(x)}}$ $Necessary\ and\ sufficient\ condition\ for\ X\ and\ Y\ to\ be\ independent\ is$ $f(x, y) = f_X(x)\, f_Y(y)$

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Unit 2: Some Special Probability Distributions	
1.	***Binomial Distribution***: $P(X = x) = nCx\, p^x q^{n-x}, x = 0, 1, 2, \ldots, n$ $n = no. of\ trials$ $p = probability\ of\ success$ $q = 1 - p = probability\ of\ failure$ $mean = np$ $variance = npq$ $SD = \sqrt{npq}$
2.	***Poisson Distribution***: $Used\ when\ n\ is\ very\ large\ and\ p\ is\ very\ small.$ $P(X = x) = \frac{e^{-\lambda}\lambda^x}{x!}, x = 0, 1, 2, \ldots, n$ $\lambda = np$ $mean = np = \lambda$ $variance = \lambda$ $SD = \sqrt{\lambda}$
3.	***Normal Distribution***: $Take\ a\ new\ random\ variable\ Z = \frac{X - \mu}{\sigma}$ $then\ use\ Z - table\ to\ find\ probability$
4.	***Exponential Distribution***: $f(x) = \lambda e^{-\lambda x}, x > 0$ $mean = \frac{1}{\lambda}$ $variance = \frac{1}{\lambda^2}$ $SD = \frac{1}{\lambda}$
5.	***Gamma Distribution***: $f(x) = \frac{\lambda^r}{\Gamma r} x^{r-1} e^{-\lambda x}, x > 0$ $mean = \frac{r}{\lambda}$ $variance = \frac{r}{\lambda^2}$ $SD = \frac{\sqrt{r}}{\lambda}$

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Unit 3: Basic Statistics	
Note: ***If data is given in the form of class then*** x_i = ***middle value of class***	
1.	***Arithmetic Mean*** $\bar{x}$ or $\mu = \frac{\sum_{i=1}^{n} x_i}{n}$ → when frequency is given, ***Weighted Arithmetic Mean*** $\bar{x}$ or $\mu = \frac{\sum_{i=1}^{n} f_i x_i}{\sum_{i=1}^{n} f_i}$ ***Expectation*** $E(X) = Mean = \sum_{i=1}^{\infty} x_i p(x_i)$ → Important Results: $E(X+k) = E(X) + k$ $E(aX \pm b) = aE(X) \pm b$ $E(X+Y) = E(X) + E(Y)$ $E(XY) = E(X)E(Y)$ if X and Y are independent random variables.
2.	For median first arrange observations in ascending order. → ***If no. of observations = n = odd*** ***Median*** $M = \left(\frac{n+1}{2}\right)^{th}$ observation → ***If no. of observations = n = even*** ***Median*** $M = \frac{\left(\frac{n}{2}\right)^{th} observation + \left(\frac{n}{2}+1\right)^{th} observation}{2}$ → when frequency is given, ***Weighted Median*** $M = l + \frac{\left(\frac{N}{2}\right) - m}{f} \times c$ l = lower limit of median class m = cumulative frequency upto median class f = frequency of median class c = class length of median class ***Median class is a class corresponding to cumulative frequency which is lowest greater than or equal to*** $\frac{N}{2}$.
3.	***Mode*** Z = Observation which occurs maximum time. → when frequency is given, ***Weighted Mode*** $Z = l + \frac{f_1 - f_0}{2f_1 - f_0 - f_2} \times c$ l = lower limit of modal class f_1 = frequency of modal class f_0 = frequency of class just above modal class f_2 = frequency of class just below modal class c = class length of modal class ***Modal class is a class with highest frequency***.

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4.	$\boldsymbol{Standard\ deviation}\ \sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{N}}$ $\rightarrow$ *when frequency is given,* $\boldsymbol{Standard\ deviation}\ \sigma = \sqrt{\frac{\sum_{i=1}^{n} f_i(x_i - \bar{x})^2}{\sum_{i=1}^{n} f_i}}$ $\boldsymbol{Standard\ deviation}\ \sigma = \sqrt{E(X^2) - [E(X)]^2}$
5.	$\boldsymbol{Variance}$ *is square of standard deviation.* $\boldsymbol{Variance}\ \sigma^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{N}$ $\rightarrow$ *when frequency is given,* $\boldsymbol{Variance}\ \sigma^2 = \frac{\sum_{i=1}^{n} f_i(x_i - \bar{x})^2}{\sum_{i=1}^{n} f_i}$ $\boldsymbol{Variance}\ V(X) = \sigma^2 = E(X^2) - [E(X)]^2$ $\rightarrow$ *Important Results*: $V(X + k) = V(X)$ $V(aX \pm b) = a^2V(X)$ $V(k) = 0$ $V(kX) = k^2V(X)$
6.	$\boldsymbol{Mean\ deviation}\ M.D. = \frac{\sum_{i=1}^{n}\lvert x_i - \bar{x}\rvert}{N}$ $\rightarrow$ *when frequency is given,* $\boldsymbol{Mean\ deviation}\ M.D. = \frac{\sum_{i=1}^{n} f_i\lvert x_i - \bar{x}\rvert}{\sum_{i=1}^{n} f_i}$
7.	$\boldsymbol{Moments}$: $\boldsymbol{Central\ Moments}\ (\boldsymbol{Moments\ about\ actual\ mean})\ \mu_r = \frac{\sum_{i=1}^{n} f_i(x_i - \bar{x})^r}{\sum_{i=1}^{n} f_i}$ $\boldsymbol{Raw\ Moments}\ (\boldsymbol{Moments\ about\ arbitrary\ mean\ a})\ \mu'_r = \frac{\sum_{i=1}^{n} f_i(x_i - a)^r}{\sum_{i=1}^{n} f_i}$ $\boldsymbol{Moments\ about\ origin}\ v_r = \frac{\sum_{i=1}^{n} f_i x_i^r}{\sum_{i=1}^{n} f_i}$ $\mu_1 = \mu'_1 - \mu'_1 = 0$ $\mu_2 = \mu'_2 - (\mu'_1)^2$ $\mu_3 = \mu'_3 - 3\mu'_2\mu'_1 + 2(\mu'_1)^3$ $\mu_4 = \mu'_4 - 4\mu'_3\mu'_1 + 6\mu'_2(\mu'_1)^2 - 3(\mu'_1)^4$ $v_1 = a + \mu'_1$ $v_2 = \mu_2 + (v_1)^2$ $v_3 = \mu_3 + 3v_1v_2 - 2(v_1)^3$ $v_4 = \mu_4 + 4v_1v_3 - 6(v_1)^2v_2 + 3(v_1)^4$
8.	$\boldsymbol{Karl\ Pearson's\ Coeffiecient\ of\ Skewness}\ S_k = \frac{Mean - Mode}{Standard\ Deviation}$ If the mode is ill-defined then $S_k = \frac{3(Mean - Median)}{Standard\ Deviation}$

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	S_k *lies betwen* -1 *and* 1. *For a positively skewed distribution*, $S_k > 0$ *For a negatively skewed distribution*, $S_k < 0$ *For a symmetrical distribution*, $S_k = 0$ ***Skewness*** $\beta_1 = \frac{\mu_3^2}{\mu_2^3}$ *For a positively skewed distribution*, $\mu_3 > 0$ *For a negatively skewed distribution*, $\mu_3 < 0$ *For a symmetrical distribution*, $\mu_3 = 0$
9.	***Kurtosis*** $\beta_2 = \frac{\mu_4}{\mu_2^2}$ *For a Leptokurtic*, $\beta_2 > 3$ *For a Platykurtic*, $\beta_2 < 3$ *For a Mesokurtic*, $\beta_2 = 3$
10.	***Correlation***: ***Karl Pearson's Correlation Coefficient*** $r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}}$ ***Spearman's Rank Correlation Coefficient*** $r = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n(n^2 - 1)}$ $d =$ *Difference between ranks R_1 and R_2 given by two judges* $N =$ *No. of pairs (contestants)*
11.	***Regression***: ***Method of least squares***: $\rightarrow y = ax + b$ (*Regression line of y on x*) $\sum y = a\sum x + nb$ $\sum xy = a\sum x^2 + b\sum x$ $\rightarrow x = ay + b$ (*Regression line of x on y*) $\sum x = a\sum y + nb$ $\sum xy = a\sum y^2 + b\sum y$ ***Regression Coefficients***: $b_{yx} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{n}(x_i - \bar{x})^2}$ $b_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{n}(y_i - \bar{y})^2}$ ***Regression line of y on x***: $y - \bar{y} = b_{yx}(x - \bar{x})$ ***Regression line of x on y***: $x - \bar{x} = b_{xy}(y - \bar{y})$ ***Correlation coefficient*** $r = \sqrt{b_{xy} \times b_{yx}}$ *If* $b_{xy} > 0, b_{yx} > 0$ *then* $r > 0$ *and if* $b_{xy} < 0, b_{yx} < 0$ *then* $r < 0$

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Unit 4: Applied Statistics: Test of Hypothesis

Large Samples: $n > 30$

1.

Critical Value Z_α	*Level of Significance* (α)		
	1%	**5%**	**10%**
Two tailed test	$\lvert Z_\alpha \rvert = 2.58$	$\lvert Z_\alpha \rvert = 1.96$	$\lvert Z_\alpha \rvert = 1.645$
Right/Left tailed test	$\lvert Z_\alpha \rvert = 2.33$	$\lvert Z_\alpha \rvert = 1.645$	$\lvert Z_\alpha \rvert = 1.28$

2. ***Test of Significance for Single Proportion***

$$Z = \frac{p - P}{\sqrt{\frac{PQ}{n}}}$$

$p =$ *Sample Proportion*

$n =$ *Sample size*

$P =$ *Total population proportion*

$Q = 1 - P$

when P and Q are not known, p and q are used.

Confidence limits:

$$95\%\ confidence\ limits = p \pm 1.96 \sqrt{\frac{PQ}{n}}$$

$$99\%\ confidence\ limits = p \pm 2.58 \sqrt{\frac{PQ}{n}}$$

3. ***Test of Significance for Difference of Proportions***

$$Z = \frac{P_1 - P_2}{\sqrt{\frac{P_1Q_1}{n_1} + \frac{P_2Q_2}{n_2}}}$$

when P_1 and P_2 are not known, p_1, p_2, q_1 and q_2 are used.

Confidence limits:

$$95\%\ confidence\ limits = (p_1 - p_2) \pm 1.96 \sqrt{\frac{P_1Q_1}{n_1} + \frac{P_2Q_2}{n_2}}$$

$$99\%\ confidence\ limits = (p_1 - p_2) \pm 2.58 \sqrt{\frac{P_1Q_1}{n_1} + \frac{P_2Q_2}{n_2}}$$

4. ***Test of Significance for Single Mean***

$$Z = \frac{\bar{x} - \mu}{\left(\frac{\sigma}{\sqrt{n}}\right)}$$

$\bar{x} =$ *sample mean*

$\mu =$ *population mean*

$\sigma =$ *population standard deviation*

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	$When\ Standard\ deviation\ of\ population\ \sigma\ is\ not\ known$ $Z = \frac{\bar{x} - \mu}{\left(\frac{s}{\sqrt{n}}\right)}$ $s = sample\ standard\ deviation$ $\boldsymbol{Confidence\ limits}$: $95\%\ confidence\ limits = \bar{x} \pm 1.96\left(\frac{\sigma}{\sqrt{n}}\right)$ $99\%\ confidence\ limits = \bar{x} \pm 2.58\left(\frac{\sigma}{\sqrt{n}}\right)$
5.	$\boldsymbol{Test\ of\ Significance\ for\ Difference\ of\ Means}$ $Z = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\left(\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}\right)}}$ $When\ Standard\ deviations\ of\ population\ \sigma_1\ and\ \sigma_2\ are\ not\ known$ $Z = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$ $\boldsymbol{Confidence\ limits}$: $95\%\ confidence\ limits = (\overline{x_1} - \overline{x_2}) \pm 1.96\sqrt{\left(\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}\right)}$ $99\%\ confidence\ limits = (\overline{x_1} - \overline{x_2}) \pm 2.58\sqrt{\left(\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}\right)}$
6.	$\boldsymbol{Test\ of\ Significance\ for\ Difference\ of\ S.D.}$ $Z = \frac{s_1 - s_2}{\sqrt{\left(\frac{\sigma_1^2}{2n_1} + \frac{\sigma_2^2}{2n_2}\right)}}$ $When\ Standard\ deviations\ of\ population\ \sigma_1\ and\ \sigma_2\ are\ not\ known$ $Z = \frac{s_1 - s_2}{\sqrt{\left(\frac{s_1^2}{2n_1} + \frac{s_2^2}{2n_2}\right)}}$
$\boldsymbol{Small\ Samples: n \leq 30}$	
7.	$\boldsymbol{t - Test: Test\ of\ Significance\ for\ Single\ Mean}$ $t = \frac{\bar{x} - \mu}{\left(\frac{s}{\sqrt{n-1}}\right)}\ where\ s = \sqrt{\frac{\sum(x - \bar{x})^2}{n}}\ with\ degree\ of\ freedom\ (df)\ v = n - 1$

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	Confidence limits: $95\%\ confidence\ limits = \bar{x} \pm t_{0.05}\left(\frac{s}{\sqrt{n-1}}\right)$ $99\%\ confidence\ limits = \bar{x} \pm t_{0.01}\left(\frac{s}{\sqrt{n-1}}\right)$
8.	$\boldsymbol{t - Test: Test\ of\ Significance\ for\ Difference\ of\ Means}$ $t = \frac{\bar{x}-\bar{y}}{s\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}}\ where\ s = \sqrt{\frac{\sum(x-\bar{x})^2+\sum(y-\bar{y})^2}{n_1+n_2-2}}\ or\ s = \sqrt{\frac{n_1 s_1^2+n_2 s_2^2}{n_1+n_2-2}}$ $with\ degree\ of\ freedom\ (df)\ v = n_1+n_2-2$ ***Confidence limits***: $95\%\ confidence\ limits = (\bar{x}-\bar{y}) \pm t_{0.05}\left(\frac{1}{s\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}}\right)$ $99\%\ confidence\ limits = (\bar{x}-\bar{y}) \pm t_{0.01}\left(\frac{1}{s\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}}\right)$
9.	$\boldsymbol{t - Test: Test\ of\ Significance\ for\ Correlation\ Coefficients}$ $t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}\ with\ degree\ of\ freedom\ (df)\ v = n-2$
10.	$\boldsymbol{Snedecor's\ F - Test\ for\ Ratio\ of\ Variances}$ $F = \frac{S_1^2}{S_2^2}\ where\ S_1^2 > S_2^2$ $S_1^2 = \frac{\sum(x-\bar{x})^2}{n_1-1}\ and\ S_2^2 = \frac{\sum(y-\bar{y})^2}{n_2-1}$ $with\ numerator\ df\ v_1 = n_1-1\ and\ denominator\ df\ v_2 = n_2-1$ $if\ s_1 and\ s_2\ (Sample\ SD)\ are\ given\ then\ S_1^2 = \frac{n_1 s_1^2}{n_1-1}\ and\ S_2^2 = \frac{n_2 s_2^2}{n_2-1}$
11.	$\boldsymbol{Chi - Square\ Test: Goodness\ of\ Fit}$ $\chi^2 = \sum\frac{(f_o-f_e)^2}{f_e}\ with\ degree\ of\ freedom\ (df)\ v = n-1$ $\boldsymbol{Chi - Square\ Test\ for\ Independece\ of\ Attributes}$ $\chi^2 = \sum\frac{(f_o-f_e)^2}{f_e}\ with\ df\ v = (no.of\ rows - 1)(no.of\ colums - 1)$ $f_e = \frac{(Row\ total)\times(Column\ total)}{Total\ frequency} = \frac{(A_i)(B_j)}{N}$

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Unit 5: Curve Fitting by Numerical Method	
1.	***Linear Approximation***: • *Equations for the best fitting straight line* $\boldsymbol{y = a + bx}$ $\Sigma xy = a\Sigma x + b\Sigma x^2$ $\Sigma y = na + b\Sigma x$ • *Equations for the best fitting straight line* $\boldsymbol{y = ax + b}$ $\Sigma xy = b\Sigma x + a\Sigma x^2$ $\Sigma y = nb + a\Sigma x$
2.	***Least Square Approximation***: • *Equations for the best fitting parabola of second degree* $\boldsymbol{y = ax^2 + bx + c}$ $\Sigma x^2 y = a\Sigma x^4 + b\Sigma x^3 + c\Sigma x^2$ $\Sigma xy = a\Sigma x^3 + b\Sigma x^2 + c\Sigma x$ $\Sigma y = a\Sigma x^2 + b\Sigma x + nc$ • *Equations for the best fitting parabola of second degree* $\boldsymbol{y = a + bx + cx^2}$ $\Sigma x^2 y = c\Sigma x^4 + b\Sigma x^3 + a\Sigma x^2$ $\Sigma xy = c\Sigma x^3 + b\Sigma x^2 + a\Sigma x$ $\Sigma y = c\Sigma x^2 + b\Sigma x + na$
3.	**Non-polynomial Approximation OR Non-linear Regression** $y = ae^{bx}$ *yields* • *Taking Logarithm on both sides* $\log y = \log a + bx$ • *Denoting* $\log y = Y$ *and* $\log a = A$, *the above equation becomes* • $Y = A + bx$ *which is a straight line.* • *From above equation* A, b *can be found & consequently* $a = Antilog\ A$ *can be calculated.* $y = ax^b$ *yields* • *Taking Logarithm on both sides* $\log y = \log a + b \log x$ • *Denoting* $\log y = Y, \log a = A$ *and* $\log x = X$ *the above equation becomes* • $Y = A + bX$ *which is a straight line.* • *From above equation* A, b *can be found & consequently* $a = Antilog\ A$ *can be calculated.* $y = ab^x$ *yields* • *Taking Logarithm on both sides* $\log y = \log a + x \log b$ • *Denoting* $\log y = Y, \log a = A$ *and* $\log b = B$ *the above equation becomes* • $Y = A + Bx$ *which is a straight line.* • *From above equation* A, B *can be found & consequently* $a = Antilog\ A$ *and* $b = Antilog\ B$ *can be calculated.*

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