Information Transmission in Brief

Term	Discrete Random Variables (DRV) System	Continues Random Variables (CRV) System
Self-Information	$I_{xi} = -\,Log_b\, p(x_i)$ b-unit of information	$I_{xi} = -\,Log_b\, f(x)$ b-unit of information
Information Units	For b=10 (Hartley unit), b=e (natural unit or Nat.), and the most common base is b=2 (Bit). For unit conversion (Z_{bits}=Logz/Log2 = Lnz/Ln2)	
Source Entropy	$H(x) = E[I_{xi}] = \overline{Ixi} = -\sum_x P(x_i)\ LogP(x_i)$	$H(x) = E[I_{xi}] = \overline{Ixi} = -\int_{-\infty}^{\infty} f(x).Logf(x)dx$
Mutual Information	$I_{x:y} = I_x - I_{x\|y} = -Log\,p(x) + Log\,p(x\|y) = Log\,\frac{p(x\|y)}{p(x)}$ $I_{x:y} = I_y - I_{y\|x} = -Log\,p(y) + Log\,p(y\|x) = Log\,\frac{p(y\|x)}{p(y)}$	$I_{x:y} = I_x - I_{x\|y} = -Log\,f(x) + Log\,f(x\|y) = Log\,\frac{f(x\|y)}{f(x)}$ $I_{x:y} = I_y - I_{y\|x} = -Log\,f(y) + Log\,f(y\|x) = Log\,\frac{f(y\|x)}{f(y)}$
Average Mutual Information	$I = \sum_y \sum_x P(x_i,y_j)\,Log\frac{p(x_i\|y_j)}{p(x_i)} = \sum_y \sum_x P(x_i,y_j)\,Log\frac{p(y_j\|x_i)}{p(y_j)}$	$I = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y).Log\frac{f(x\|y)}{f(x)}\,dxdy = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y).Log\frac{f(x\|y)}{f(x)}\,dxdy$
Receiver Entropy	$H(y) = -\sum_y P(y_j)\ LogP(y_j)$	$H(x) = -\int_{-\infty}^{\infty} f(y).Logf(y)dy$
Conditional Entropies – Noise	$H(y\|x) = -\sum_x \sum_y P(x_i,y_j)\ LogP(y_j\|x_i)$	$H(y\|x) = -\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y).Log\,f(y\|x)\,dxdy$
Conditional Entropies – Losses	$H(x\|y) = -\sum_x \sum_y P(x_i,y_j)\ LogP(x_j\|y_i)$	$H(x\|y) = -\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y).Log\,f(x\|y)\,dxdy$
Joint or System Entropy	$H(x,y) = -\sum_x \sum_y P(x_i,y_j)\ LogP(x_i,y_j)$	$H(x,y) = -\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y).Log\,f(x,y)\,dxdy$
Useful Relations (Prove them?)	I=H(y)-H(y|x) , H(x,y) = H(x) + H(y|x) , H(x,y) =I + H(y|x) + H(x|y) The units for all H and I are bit/symbol I=H(x)-H(x|y) , H(x,y) = H(y) + H(x|y) , H(x,y) = H(x) + H(y) – I	
Noiseless Channel	$P(y_j\|x_i) = P(x_j\|y_i) = 1$ for i=j then H(y|x) = H(x|y) = 0 and H(x)=H(y)=H(x,y) = I = 0 for i≠j (no error in the channel)	
Maximum source entropy	$H_{max}(x)$= LogM, with $P(x_i) = 1/M$, for all x_i M= No. of source symbols	$H_{max}(x) = \log\sqrt{2\pi e\sigma^2}$, with $f(x) = \frac{1}{\sigma\sqrt{2\pi}}e^{-(x-\overline{x})^2/2\sigma^2}$ (i.e the pdf of CRV is Gaussian or Normal)
Source efficiency	$\eta = (H(x)/H_{max}(x)).100\%$ and Redundancy = $(1-\eta).100\%$, (both H(x) and H_{max} should have the same units)	
Capacity of channel	For symmetric, where the rows contents of p(y|x) matrix are the same $C = I_{max} = H_{max}(y) - Hy\|x)$ with $H_{max}(y)$ = LogN and N= No. of received symbols and $H(y\|x) = -\sum_y P(y_j\|x_i)\ LogP(y_j\|x_i)$ For non-symmetric channel, one should derive I=f(p(x_i)) with respect to source symbol probabilities {p(x_i)} to find {$p_m(x_i)$}	Assumptions : Source and noise are: Gaussian with zero means, the channel is additive (i.e. AWGN), S=signal power, N=Noise Power, B=channel Bandwidth, N_o=One sided power spectral density of AWGN C= Log_2(1+ S/N) bit/symbol C_r=2.B.C C_r=B. Log_2(1+ S/N) bit/sec(bps) C_r=B. Log_2(1+ S/B.N_o)
Channel efficiency and redundancy	$\eta = (I/C).100\%$ Redundancy = $(1-\eta).100\%$	Spectral Efficiency = C_r/B= Log_2(1+ S/N) (bit/sec/Hz) η= (Actual Rate/ C_r).100% Redundancy = $(1-\eta).100\%$