*Show your work and underline your final answer. Numeric answers must include units. Books, notes and calculators allowed. No other electronic devices allowed.*

1. A system uses differential signalling over a wire pair. You connect two channels of an oscilloscope to measure the voltages on the two conductors. These are labelled `D+` and `D-` (the differential voltage is positive when `D+` is greater than `D-`). At one point in time `D+` has a voltage of 3V and `D-` has a voltage of 2V. What are the common-mode and differential voltages at this time?

$D+ = 3$
$D- = 2$

$V_{diff} = D+ - D- = 3-2 = 1$

$V_{cm} = \frac{D+ + D-}{2} = \frac{3+2}{2} = 2.5$

2. A communication system transmits data using four voltages: −3V, −1V, +1V, and +3V. The receiver uses three decision thresholds half-way between the voltages. The channel adds zero-mean Gaussian noise with a voltage of $0.43V_{rms}$. $\mu = 0 \quad \sigma = 0.43\ V_{rms}$

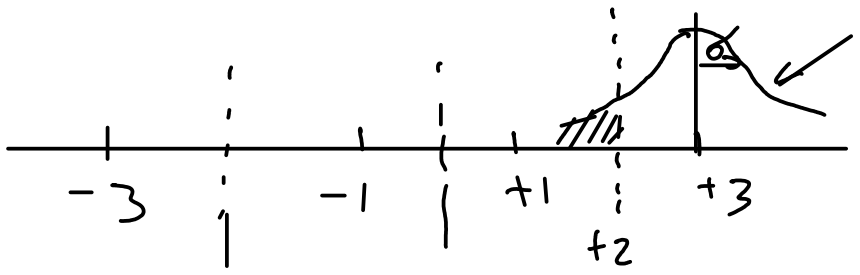
   (a) What is the average signal power, assuming a 1Ω resistance, if each of the four levels is equally probable? What is the noise power? What is the SNR in dB?

$P_{avg} = \frac{1}{4}\frac{(-3)^2}{1} + \frac{1}{4}\frac{(-1)^2}{1} + \frac{1}{4}\frac{(1)^2}{1} + \frac{1}{4}\frac{(3)^2}{1}$

$= \frac{20}{4} = 5W \qquad P_{noise} = \frac{V^2}{R} = \frac{(0.43)^2}{1} = 0.185$

$SNR = \frac{S}{0.185} = 27 \qquad SNR(dB) = 10\log(27) = 14\ dB.$

   (b) What is the probability of (symbol) error if a level of +3 V is transmitted?




$P(s < V=2) = P\left(\frac{2-\mu}{\sigma}\right) = P\left(\frac{2-3}{0.43}\right) \approx -2.3$

$P() \approx 1\%$