No materials, no calculator. Prepared by M. Valkama.

NB: Pay special attention to clear handwriting. If I cannot read your text with reasonable effort, your paper cannot be unfortunately graded. So, please, try to write your responses and solutions in a clear manner. Thank you. Enjoy. ☺

1. Explain shortly the following concepts: a) spectrum, b) intermodulation distortion, c) cross-correlation, d) spectral density, e) white noise, f) Gaussian noise. No need to dwell on details, rough explanations which show your understanding are enough. (6p)

2. Assume $x(t)$ is real-valued stationary white noise. Suppose another stationary random signal $y(t)$ is created as $y(t) = x(t) + x(t - T)$ where T is a known constant. First, calculate the autocorrelation function of $y(t)$. Then, calculate also the spectral density of $y(t)$ and illustrate it graphically. Is $y(t)$ white noise ? (4p)

   Recap: Autocorrelation for stationary real-valued signal $y(t)$ is defined as $R_y(\tau) = E[y(t)y(t-\tau)]$

3. a) A general bandpass signal can be expressed mathematically as

$$x_{BP}(t) = A(t)\cos(\omega_C t + \varphi(t)) = x_I(t)\cos(\omega_C t) - x_Q(t)\sin(\omega_C t)$$

   Sketch an example time-domain waveform and the corresponding amplitude spectrum of this kind of a bandpass signal. In the above expression, what do the quantities or functions $A(t)$, $\phi(t)$ and ω_C (or f_C) represent physically? Sketch also the amplitude spectrum of the corresponding lowpass equivalent signal. (3p)

   b) Explain shortly how the following carrier modulation methods utilize the above bandpass signal structure: (2p)
   - amplitude modulation, AM
   - dual-sideband modulation, DSB
   - phase modulation, PM
   - I/Q modulation

Maximum points: 6+4+5 = 15p.