### Question 1

(a) Write the joint probability density function for multi-variate random variables, \( X_1, X_2, X_3, \ldots, X_n \).

(b) Define Central limit theorem. Let \( Z \) be the sum of two independent random variables \( X \) and \( Y \). Find the density of \( Z \) if the densities of \( X \) and \( Y \) are identical and is given by the difference of unit step functions \( u(x+1) \) and \( u(x-1) \).

(c) Describe joint and marginal probability. Consider an urn containing two red and two black balls. Let two balls are drawn sequentially from the urn without replacement. What is the array of joint probabilities for the first and second draws?

**OR**

(c') Show that the random process \( X(t) = A \cos(\omega_0 t + \theta) \) is wide sense stationary if it is assumed that \( A \) and \( \omega_0 \) are constants and \( \theta \) is a uniformly distributed random variable on the interval \([0, 2\pi]\).

### Question 2

(a) Define the probability distribution and density functions for a random variable \( X \). Then, show that the mean value and variance for \( X \) having the uniform density function as:

\[
    f_X(x) = \begin{cases} 
    1/(b-a) & a \leq x \leq b \\
    0 & \text{elsewhere} 
    \end{cases}
\]

is \( \bar{X} = E[X] = (a + b)/2 \) and \( \sigma_X^2 = (b-a)^2 / 12 \).
| (b) | A random process is defined by \( X(t) = X_0 + Vt \) where \( X_0 \) and \( V \) are statistically independent random variables uniformly distributed on intervals \([X_{01}, X_{02}]\) and \([V_1, V_2]\) respectively. Find (i) the mean (ii) the autocorrelation and (iii) the autocovariance functions of \( X(t) \). (iv) Is \( X(t) \) stationary in any sense? If so, state the type. |

\( (9) \)

| OR |

| Q2' (a) | Define autocorrelation function (ACF) for a random process \( X(t) \). Modify the formula if \( X(t) \) is wide-sense stationary. Discuss the properties of ACF. |

\( (9) \)

| (b) | If \( X(t) \) is a stationary random process having a mean, \( E[X(t)] = 3 \) and autocorrelation function \( R_{xx}(\tau) = 9 + 2e^{-|\tau|} \), find: the mean value and the variance of the random variable \( Y = \int_0^2 X(t) \, dt \). |

\( (6) \)

| Q3 | Define Correlation, Covariance and Orthogonality for two random variables \( X \) and \( Y \). Then define random variables \( V \) and \( W \) by \( V = X + aY \) and \( W = X - aY \). where 'a' is a real number and (i) \( X \) and \( Y \) are random variables. Determine 'a' in terms of moments of \( X \) and \( Y \) such that \( V \) and \( W \) are orthogonal. (ii) If \( X \) and \( Y \) are Gaussian, show that \( W \) and \( V \) are statistically independent if \( a^2 = \frac{\sigma_Y^2}{\sigma_X^2} \), where \( \sigma_X^2 \) and \( \sigma_Y^2 \) are the variances of \( X \) and \( Y \) respectively. |

\( (15) \)

| OR |

| Q3' (a) | Define power spectral density function. Discuss any three properties in brief. |

\( (7) \)

| (b) | A wide sense stationary random process \( X(t) \) is used to define another process by \( Y(t) = \int_{-\infty}^{\infty} h(\xi)X(t-\xi) \, d\xi \) where \( h(t) \) is some real function having a Fourier transform \( H(\omega) \). Show that the power spectrum of \( Y(t) \) is given by: \( S_{yy}(\omega) = S_{xx}(\omega)|H(\omega)|^2 \). |

\( (8) \)
|Q4| (a) Discuss the different approaches to the development of linear adaptive filter. | (8) |

(b) A first order real valued autoregressive (AR) process \( u(n) \) satisfies the real valued difference equation:
\[
u(n) + a_1 u(n-1) = v(n)\]
where \( a_1 \) is a constant and \( v(n) \) is a white noise process with variance \( \sigma_v^2 \).

(i) Show that if \( v(n) \) has non zero mean, the AR process \( u(n) \) is non-stationary.

(ii) For the case when \( v(n) \) has non-zero mean and the constant \( a_1 \) satisfies the condition \( |a_1| < 1 \), show that the variance of \( u(n) \) is given by:
\[
\text{var}[u(n)] = \frac{\sigma_v^2}{1 - a_1^2}
\]

|Q5| (a) Derive the Weiner-Hopf equation to minimize the mean square estimate of a given wide sense stationary random process. | (10) |

(b) Consider the Wiener Filtering problem with:
\[
R = \begin{bmatrix} 1 & 0.5 \\ 0.5 & 1 \end{bmatrix} \quad \text{and} \quad p = \begin{bmatrix} 0.5 \\ 0.25 \end{bmatrix}
\]
where \( R \) is the correlation matrix of the input vector \( u(n) \) and \( p \) is the cross correlation vector between \( u(n) \) and the desired response \( d(n) \). The variance of the desired response is 0.5.

(i) Evaluate the tap weights of the filter.

(ii) Find the minimum mean squared error produced by this filter. | (5) |
2010-2011
M.TECH. (III SEMESTER) EXAMINATION
(ELECTRICAL ENGINEERING)
DIRECT ENERGY CONVERSION
(EB-771)

Maximum marks: 75

Duration: Three Hours

Answer four questions only.
Question No.1 is compulsory.
Assume any suitable value to missing data.
Symbols used have their usual meanings.

1. Write short notes on any three of the following: 5 x 3
   (a) Comment on the status of the world present conventional sources and their availability for power generation.
   (b) Green house effect and global warming
   (c) Single basin tidal energy conversion system.
   (d) Uses of OTEC other than power production.
   (e) Comment on thin film PV technology

2. (a) Classify wave energy converters based on the position in the sea. Describe with neat sketches the working of water column wave device. 10
   (b) Comment on cost and reliability of wave energy. 05
   (c) Give advantages and limitations of wave energy conversion. 05

3. (a) Explain what you mean by Ocean thermal energy conversion. 04
   (b) Give brief history of OTEC. 05
   (c) Discuss the plant design and location of OTEC systems. 06
   (d) What researches are needed to accelerate the development of OTEC systems? 05

4. (a) How Tides are produced? Discuss the single basin double effect tidal scheme. 07
   (b) Discuss the I-V characteristics of solar cell with varying solar isolation. 07
   (c) Discuss the working of the solar pond and its applications. 06

5. (a) Explain the terms Magetohydrodynamics and MHD Electrical power generation. 04
   (b) Define and explain the terms associated with MHD Power generation:
   (i) Plasma 08
   (ii) Lorentz force
(iii) Loading factor
(iv) Hall effect.

(c) Derive expressions for the power output, retarding force and pressure difference per unit volume of an MHD generator.

6.(a) What is seed and why it is added to MHD plasma? Give the ionization energy of Cesium, Potassium and Sodium. Discuss the reduction of \( \text{SO}_x \) and \( \text{NO}_x \) seed recovery process from MHD Channel.

(b) With a neat sketch, discuss the working of a FBR coupled close cycle LMMHD generating system. Give the efficiency and applications of LMMHD systems.