KHULNA UNIVERSITY OF ENGINEERING &TECHNOLOGY

B.Sc. Engineering 2nd Year 1st Term Examination, 2017

Department of Electronics and Communication Engineering

ECE-2101

(Analog Electronics II)

TIME: 3 hours FULL MARKS: 210

N.B. i) Answer **ANY THREE** questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

SECTION A

(Answer **ANY THREE** questions from this section in Script A)

1. a) Define tuned amplifier. Explain the tuned amplifier circuit with its applications. (08)
   b) What are the differences between the single tuned amplifier and double tuned amplifier? How does the selectivity of a double tuned amplifier depend on the types of coupling? Explain it graphically. (14)
   c) Why tuned circuits are not used to amplify low frequencies? (05)
   d) The dynamic impedance of a parallel resonant circuit is $500k\Omega$. The circuit consist of a $250pF$ ccapacitor in parallel with a coil of resistance 100Ω. Calculate (i) the coil inductance, (ii) the resonant frequency and, (iii) Q-factor of the circuit. (08)

2. a) Explain the ac equivalent circuit of a single tuned amplifier in terms of the three input frequency conditions, i.e., (i) $f_{in} > f_r$, (ii) $f_{in} = f_r$, and (iii) $f_{in} < f_r$. Here, the symbols have their usual meanings. (12)
   b) Describe the circuit operation and feedback fraction of Hartley Oscillator with necessary diagram. (10)
   c) Explain the principle of phase shift circuit of a phase shift oscillator. (08)
   d) What is the frequency of oscillation in following figure? What is the feedback fraction? How much voltage gain does the circuit need to start oscillation. (05)

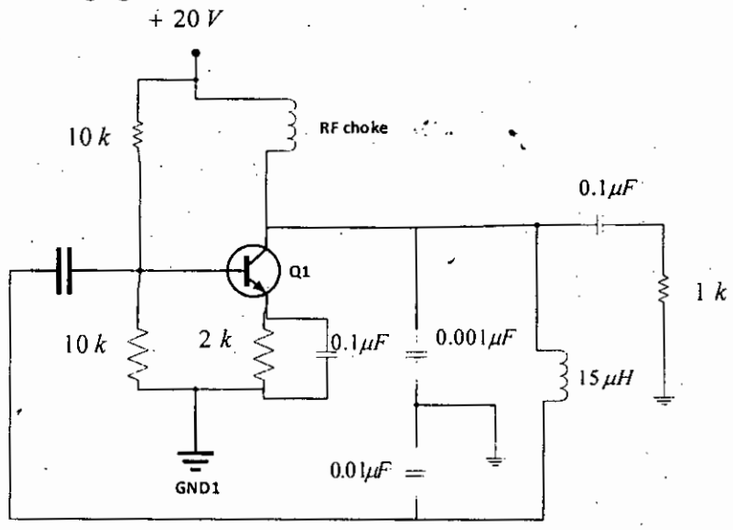

Fig.2(d)

3. a) Explain the frequency response of crystal. What are the limitations of LC and RC oscillators? (08)
   b) Explain the operation of UJT relaxation oscillator. (10)
   c) The ac equivalent circuit of a crystal has these values: $L = 1H$, $C = 0.001pF$, $R = 1000\Omega$ and $C_m = 20pF$. Calculate f_s and f_p of the crystal. (07)
   d) What is Barkhausen criterion? Why is it important for oscillator circuit? (10)

4. a) Derive the expressions for input impedances of both the voltages-series and voltage-shunt feedback circuits. (10)
   b) Explain the effect of negative feedback on gain and bandwidth of a feedback amplifier (10)

c) Prove that the total harmonic distortion of feedback amplifier is lower than that of without feedback amplifier.

d) An amplifier has an open-circuit voltage gain of 70db and an output resistance of $1.5k\Omega$. Determine the minimum value of load resistance so that voltage gain is not more than 67db. (05)

SECTION B

(Answer **ANY THREE** questions from this section in Script B)

5. a) What is op-amp? Explain the single ended and double ended operations of op-amp. (10)

b) Define Virtual Ground for inverting op-amp amplifier and Virtual short for non-inverting op-amp amplifier. (07)

c) Why an open-loop op-amp is not suitable for linear applications? Write down the applications of positive feedback and negative feedback. (07)

d) For inverting amplifier of Fig. 5(d), $R_1 = 470\Omega$ and $R_F = 4.7k\Omega$. Calculate the values of A_F, R_{iF}, R_{oF}, f_F, and V_{ooT} ; where the 741C op-amp having the following parameters: $A = 200{,}000, R_i = 2M\Omega, R_o = 75\Omega, f_o \cong 5Hz$, supply voltage $= \pm 15V$, output voltage swing $= \pm 13V$. (11)

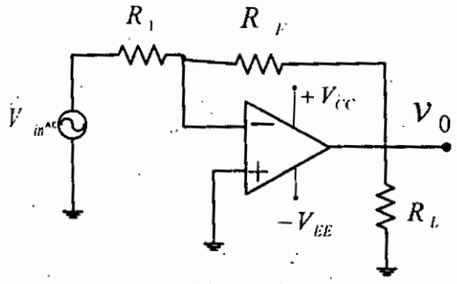

Fig. 5(d)

6. a) Define CMMR. Explain the use of an op-amp as an integrator. (08)

b) Prove that depending on the relationship between the feedback resistor (R_F) and input resistors R_a, R_b and R_c of an op-amp circuit can be used as a summing amplifier, a scaling amplifier, or an averaging amplifier. (09)

c) What is cut-off frequency? What are the differences between band-pass and band stop filters? (07)

d) In the circuit of Fig. 6(d), $R_1 C_F = 1$ second, and the input is a step (dc) voltage, as shown in Fig. 6(d). Determine the output voltage and sketch it. Assume that the op-amp is initially nulled. (05)

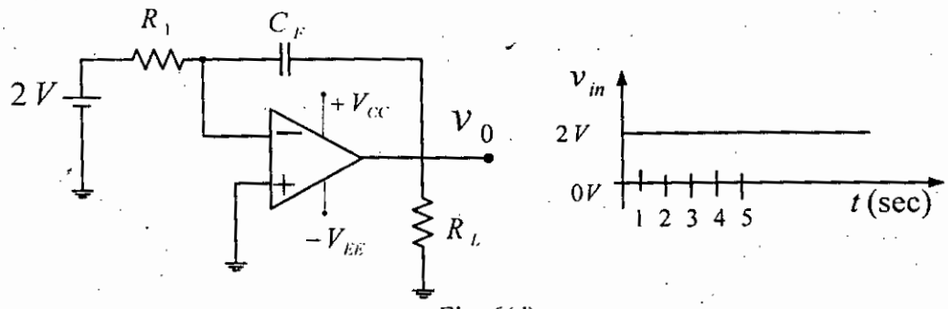

Fig. 6(d)

e) Design a high-pass filter at a cut-off frequency of 1KHz with a passband gain of 2. (06)

7. a) What is Schmitt trigger? Describe its input-output response with hysteresis properties. (10)

b) Define multivibrator. Explain the operation of bistable multivibrator using necessary diagrams. (10)

c) Explain the internal block diagram of 555 IC. (07)

d) In the astable multivibrator of Fig. 7(d), $R_A = 2.2k\Omega$, $R_B = 3.9k\Omega$, and $C = 0.1\mu F$. Determine the positive pulse width t_c, negative pulse width t_d, and free-running frequency f_0. (08)

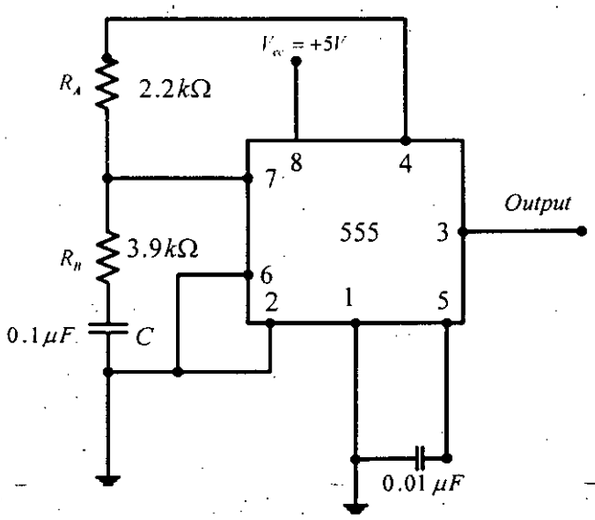

Fig. 7(d)

8. a) What do you mean by the order of filter? Note down the pros and cons of the Butterworth filter. (10)

b) What do you mean by speed up capacitor? (05)

c) Draw the output wave shapes of the following clipper circuits. Assume diodes are ideal. (10)

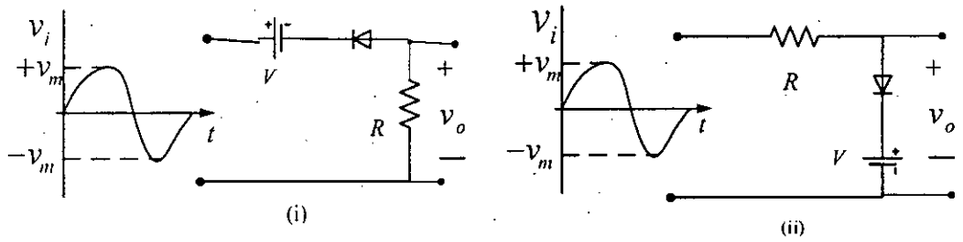

Fig.8(c)

d) What do you know about PLL? With the help of block diagram briefly explain its construction and operating principle. (10)

KHULNA UNIVERSITY OF ENGINEERING &TECHNOLOGY

B.Sc. Engineering 2nd Year 1st Term Examination, 2017

Department of Electronics and Communication Engineering

ECE-2103

(Digital Electronics & Logic Circuits)

TIME: 3 hours FULL MARKS: 210

N.B. i) Answer **ANY THREE** questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

SECTION A

(Answer **ANY THREE** questions from this section in Script A)

1 a) Convert the following numbers from the given base to the bases indicated: (12)
i. Decimal number 238.7 to base 3, base 4 and base 7.
ii. Hexadecimal 2CA5.D to decimal, octal and binary.

b) A and B are integer variables in a computer program with $A = (25)_{10}$ and $B = -(46)_{10}$. Assuming that the computer uses 8-bit two's complement arithmetic, show how it would compute A+B, A-B, B-A and -A-B. (13)

c) Define the following terms: (10)
(i) Error detection code, (ii) Reflected code, (iii) Self-complementary code, (iv) Decoder, (iv) PLA

2 a) Express the following functions in a sum of Minterms and a product of Maxterms: (12)
i. $F(A, B, C) = (A' + B)(B' + C)$
ii. $F(x, y, z) = (xy + z)(y + xz)$

b) Simplify the following logic circuit as shown in Fig. 2(b). (12)

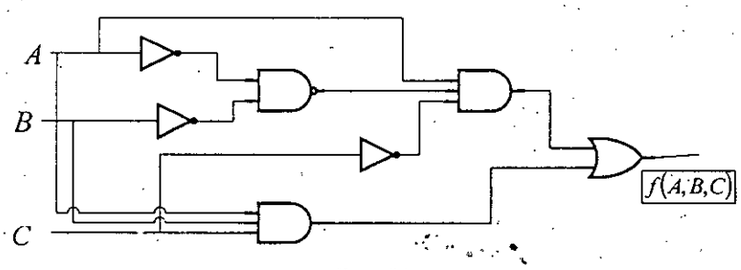

Fig. 2(b)

c) The following Boolean expression: (11)

$$BE + B'DE'$$

is a simplified version of the expression?

$$A'BE + BCDE + BC'D'E + A'B'DE' + B'C'DE'$$

Are there any don't care conditions? If so, what are they?

3 a) For the following Fig 3(a), where a analog-to-digital converter is monitoring the dc voltage of a 12V storage battery on an orbiting spaceship. The converters output is a four-bit binary number, ABCD, corresponding to the battery voltage in steps of 1V, with A as the MSB. The converter's binary outputs are fed to a logic circuit that is to produce a HIGH output as long as the binary value is greater than $0110_2 = 6_{10}$; that is, the battery voltage is greater than 6V. Design this logic circuit. (13)

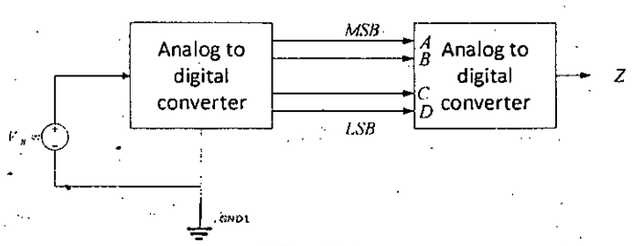

Fig. 3(a)

b) Design a combinational circuit that converts a decimal digit from the 2,4,2,1 code to the 8,4,-2,-1 code. (11)

c) Design a 16-to-1 multiplexer by using 4-to-1 multiplexers that can be used for a tree type network. (11)

4 a) Design a combinational circuit using a ROM. The circuit accepts 3-bit number and generates an output binary number equal to the square of the input number. (13)

b) Show that $A \odot B \odot C \odot D = \sum(0,3,5,6,9,10,12,15)$ (10)

c) A combination circuit is defined by the following three equations: $F_1 = x'y' + xyz'$, $F_2 = x' + y$, $F_3 = xy + x'y'$. Design the circuit with a decoder and external gates. (12)

SECTION B

(Answer **ANY THREE** questions from this section in Script B)

5 a) What is sequential circuit? Draw the block diagram of a sequential circuit. (05)

b) Why race around condition occurs in JK flip-flop? How this problem can be overcome? (10)

c) Write down the characteristics table and excitation table of RS, JK, D and T flip-flop. (10)

d) Show the operation of the D-type edge triggered flip-flop with necessary diagram. (10)

6 a) A sequential circuit has one input and one output. The state diagram is shown in Figure 6(a). Design the sequential circuit with T flip-flops. (12)

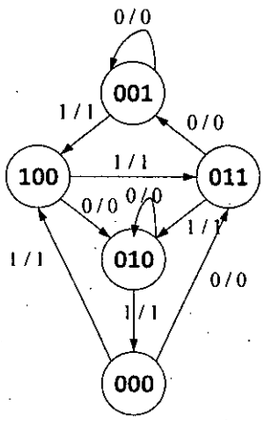

Fig. 6(a)

b) What is register? Design a 4-bit register with parallel load using D flip-flops and explain its operation. (12)

c) Design a counter that counts the decimal digits according to $84\bar{2}\bar{1}$ code using T flip-flop. (11)

7 a) The content of a 4-bit shift register is initially 1101. The register is shifted six times to right with the serial input being 101101. What is the content of the register after each shift? (10)

b) Design a mod-6 counter using a counter with parallel load. (12)

c) Show that in a dual slop A/D converter, the output of the counter is proportional to the analog voltage. (12)

8 a) What is memory element? Show the information transfer process in a magnetic core memory during write operation. (08)

b) Write short notes on EPROM and E^2PROM. (08)

c) Compare weight-resister and R-2R ladder D/A converter. (09)

d) Convert an S-R flip-flop to a J-K flip flop. (10)

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

B.Sc. Engineering 2nd Year 1st Term Examination, 2017

Department of Electronics and Communication Engineering

ECE 2105

(Science of Materials)

TIME: 3 hours FULL MARKS: 210

N.B. i) Answer **ANY THREE** questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

SECTION A

(Answer **ANY THREE** questions from this section in Script A)

1. a) Briefly outline the importance of studying materials science and engineering. (06)
   b) Describe the BCC and HCP crystal structure with relevant examples. (08)
   c) Describe various types of crystal imperfections with proper diagram. (12)
   d) The unit cell Al is FCC with lattice constant, a=0.04049 nm. (09)
      i) How many unit cells are in the Al-foil with 0.005 cm thick and side 25 cm square.
      ii) It weighs 8.44×10^{-3}kg. How many atoms are present?

2. a) What is the basic assumption of Einstein's theory of specific heat? Derive an expression for the specific heat of a solid on the Einstein model and show that at low temperature it drops exponentially with decreasing temperature. (13)
   b) Discuss the salient features of Debye's theory of specific heat and show how far it agrees with experimental values. (12)
   c) Describe briefly the quantum free electron theory of metals introduced by Sommerfeld. What are the achievements of this model? Where does it fail? (10)

3. a) Write down the Schröndinger's wave equation for stationary states. Solve it for particles in a cubical box of side 'a' and hence obtain expression for the allowed wave functions and discrete energies of the particle. (13)
   b) What is quantum mechanical tunneling in solids? Show that the wider and higher the potential barrier, the smaller the chance of electron tunneling. (12)
   c) What is meant by polarization in dielectrics? Show that $P=E\varepsilon_0(\varepsilon_r-1)$, where the symbols have their usual meanings. (10)

4. a) Briefly discuss different polarization mechanisms in dielectrics and their temperature dependence. (12)
   b) Obtain Clausius-Mosotti equation for dielectrics and explain how it can be used to determine the dipole moment of a polar molecule. (13)
   c) Consider a parallel plate capacitor having an area of 6.45×10^{-4} m^2 and a plate separation of 2×10^{-3} m across which a potential of 12 V is applied. If a material having a dielectric constant of 6.0 is positioned within the region between plates, compute i) the electric displacement and ii) the polarization. (10)

SECTION B

(Answer **ANY THREE** questions from this section in Script B)

5. a) Explain the following terms: (12)
i) Magnetic dipole moment, ii) Bohr magnetron, iii) Magnetizing field, and iv) Magnetic permeability.

b) Show that the magnetic dipole moment per unit volume is the same as the magnetization current on the surfaces per unit length of the specimen. (12)

c) Consider a toroidal coil as shown in Fig. 5(c) whose mean circumference is l and that has N tightly wound turns around it. Suppose that the diameter of the core is $2a$ and $l>>a$. by applying Ampere's law, show that the inductance of the coil is $L=\frac{\mu_o\mu_r N^2 A}{l}$, where symbols have their usual meanings. (11)

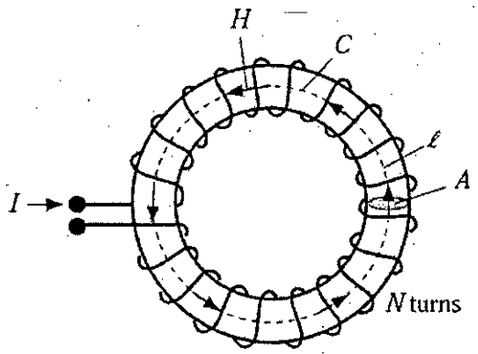

Fig. of Q.5(c)

6. a) How do you classify a material as dia or para of ferromagnetism? Explain ferrimagnetism and anti-ferromagnetism. (10)

b) Discuss the M versus H behavior of polycrystalline materials. (12)

c) Explain maximum relative permeability and initial relative permeability. (06)

d) The maximum magnetization M_{sat} in iron is about 1.75×10^6 Am^{-1}. This corresponds to all possible net spins aligning parallel to each other. Calculate the effective number of Bohr magnetrons per atom that would give M_{sat}, given that the density and relative atomic mass of iron are 7.86 gcm^{-3} and 55.85, respectively. (07)

7. a) Briefly explain Meissner effect. Why in all engineering applications of superconductor Type II materials are used. (10)

b) For GaAS, the refractive index is given by $n^2=7.10+\frac{3.78\lambda^2}{\lambda^2-0.2767}$ for the wavelength λ of 0.89 to 4.1 microns (μm). What is the refractive index of GaAs for light with a photon energy of 1 eV. (07)

c) "The refractive index of materials in general depends on the frequency"- justify the statement. (13)

d) Explain group velocity and group index. (05)

8. a) Briefly explain Kramers-Kronig relations. (10)

b) Consider a semiconductor sample with a conductivity σ, and refractive index n. Show that the absorption coefficient due to free carrier absorption (due to conductivity) is given by $\alpha=\left(\frac{1}{c\varepsilon_o}\right)\frac{\sigma}{n}$. (10)

c) An InP crystal has a refractive index (real part) n of 3.549 at a wavelength of 620 nm. The reflectance of the air-InP crystal surface at this wavelength is 0.317. Calculate the extinction coefficient K and the absorption coefficient α of InP at this wavelength. (06)

d) Explain the following terms: (09)
i) Poynting vector, ii) Lattice absorption, and iii) Rayleigh scattering.

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

B.Sc. Engineering 2nd Year 1st Term Examination, 2017

Department of Electronics and Communication Engineering

ECE 2107

(Signals & Systems)

TIME: 3 hours FULL MARKS: 210

N.B. i) Answer **ANY THREE** questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

SECTION A

(Answer **ANY THREE** questions from this section in Script A)

1. a) What is signal? Explain the operations performed on the independent variables in the processing of discrete signals. (08)

b) Determine whether the signal $x(t)=\sin 20\pi t+\sin 5\pi t$ is periodic or not. If it is periodic, then find the fundamental period. (06)

c) Determine whether $x(n)=\begin{cases} n & ; 0 \le n < 5 \\ 10-n & ; 5 \le n \le 10 \\ 0 & ; \text{otherwise} \end{cases}$ is energy or power signal and also find its energy or power. (06)

d) Sketch the following signals: (05)
i) $x(t)= 2\pi(0.5t+0.25)$ and ii) $x(t)= 5(2t+1)$

e) Sketch the single and double sided frequency spectra of the following signal: (10)
$x(t)=25\cos(5\pi t-\pi/2)$

2. a) Define system. Distinguish between: (09)
i) Linear and Non-linear system.
ii) Recursive and Non-recursive system.

b) Deduce the necessary and sufficient condition of BIBO stability of an LTI system. Also check the BIBO stability of the digital system: $y(n)=e^{-x(n)}$ (14)

c) Determine whether the discrete time system represented by the difference equation: (12)
$y(n)= x(n+1)-3x(n)+x(n-1);\ n \ge 0.$
i) Time invariant, ii) Linear, and iii) Casual

3. a) Show that the output response of a LTI system is the convolution sum of the input signal and impulse response. (08)

b) Given two sequences of length $N=4$ defined by $x_1(n)= (1,2,2,1)$ and $x_2(n)= (2,1,1,2)$. Determine their linear and periodic convolution. (12)

c) Given an RL circuit depicted in Fig. 3(c), whose input is x(t) and output is y(t). (15)

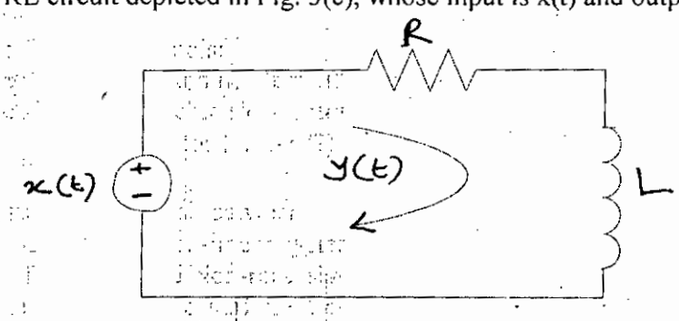

Figure of Q. 3(c)

i) Obtain the differential equation describing the system.
ii) Obtain the number of memory elements in the system.
iii) Determine the homogeneous solution of the system.
iv) Determine the particular solution of the system if input x(t)=u(t).
v) Determine the complete solution of the system if initial current through the inductor is y(0) = -1A and R=1Ω, L=1H.

4. a) State and prove the Shannon-Nyquist sampling theorem. (08)

b) Distinguish between Ideal, Natural, and Flat-top sampling techniques. (07)

c) Determine the output of the system described by the difference equation with input and initial conditions as specified. (08)

$$y(n)-\frac{1}{9}y(n-2)=x(n-1);$$

$$x(n)=u(n),\ y(-1)=1,\ y(-2)=0.$$

d) Define state of a system. Find the state variable description depicted in Fig. 4 (d). Chose the state variables $q_1(t)$ and $q_2(t)$ as the voltage across the capacitor and current through the inductor. (12)

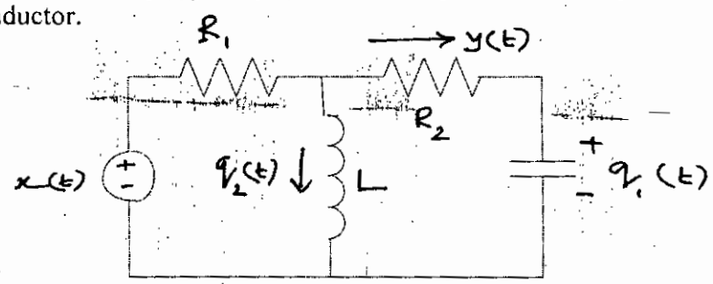

Figure of Q. 4(d)

SECTION B

(Answer **ANY THREE** questions from this section in Script B)

5. a) State necessary and sufficient conditions for the existence of the Fourier series representation for a signal. (07)

b) With regard to Fourier series representation, justify that odd function have only sine term coefficients. (06)

c) Obtain the Fourier components of the periodic square wave signal which is symmetrical with respect to the vertical axis at t=0 shown in Fig. 5(c). (12)

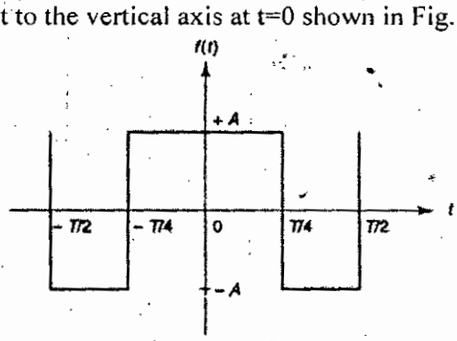

Figure of Q. 5(c)

d) In the system shown in Fig. 5(d), determine the output response of the low-pass RC network for an input signal $x(t)=e^{-\frac{t}{RC}}$. (10)

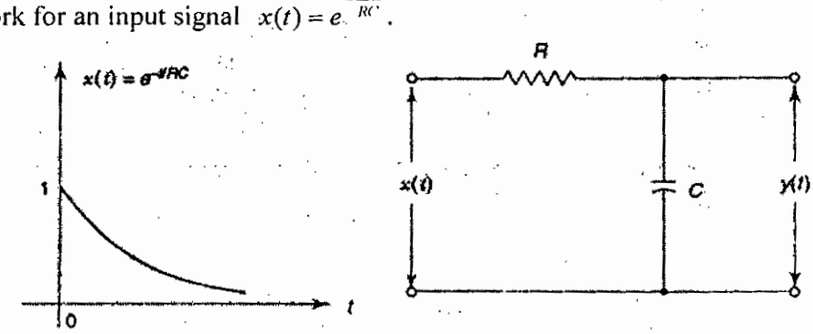

Figure of Q. 5(d)

6. a) Derive Fourier transform pair for single pulse or transient only. (10)

b) Show that the normalized Gaussian pulse is it's own Fourier transform. (10)

c) The input signal $x(t)=e^{-at}u(t)$, $a>0$ is applied to the system whose transfer function is $h(t)=e^{-bt}u(t)$, $b>0$. Determine the output signal y(t) when $b\neq a$ and $b=a$. (09)

d) Obtain the Fourier transform of the signal (06)

$$f(t)=\frac{1}{2}\left[\delta(t+1)+\delta(t+\frac{1}{2})+\delta(t-\frac{1}{2})+\delta(t-1)\right]$$

7. a) State and explain Laplace transform and its inverse transform. (06)

b) Define zeros and poles. How the stability of a system is determined? (07)

c) What is region of convergence? Explain it with an example. (08)

d) For the circuit shown in Fig. 7(d), determine the resultant current i(t) when the switch is moved from position 1 to position 2 at t=0. Initially the switch has been at position 1 for a long time to get the steady state values. (14)

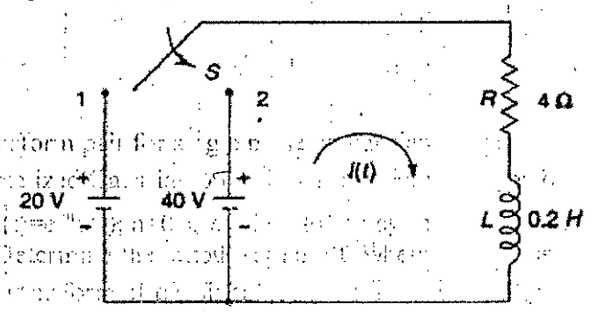

Figure of Q. 7(d)

8. a) How is z-transform obtained from Laplace transform? (06)

b) By applying the time shifting property, determine the inverse z-transform of the signal $X(z)=\frac{z^{-1}}{1-3z^{-1}}$. (07)

c) Determine the z-transform of the following sequences: (09)

i) $\delta(n-5)$, ii) $e^{jn\pi/4}u(n)$, iii) $\left(\frac{1}{3}\right)^n u(-n)$

d) Determine the inverse z-transform of $X(z)=\frac{z}{3z^2-4z+1}$ if the region of convergence are (13)

i) $|z|>1$, ii) $|z|<\frac{1}{3}$, and iii) $\frac{1}{3}<|z|<1$.

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

B.Sc. Engineering 2nd Year 1st Term Examination, 2017

Department of Electronics and Communication Engineering

Math-2109

(Mathematics III)

TIME: 3 hours FULL MARKS: 210

N.B. i) Answer **ANY THREE** questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

SECTION A

(Answer **ANY THREE** questions from this section in Script A)

1. a) Find the Laplace transform of the following functions: (15)
(i) $t\cos 2te^{-2t}$; (ii) $\frac{e^{-at}-e^{-bt}}{t}$.

b) Define periodic function. Find the Laplace transform of the function, (10)

$$F(t) = \begin{cases} \sin t, & 0 < t < \pi \\ 0, & \pi < t < 2\pi \end{cases}, \text{ where } f(t+2\pi) = f(t)$$

c) Apply the convolution theorem for inverse Laplace transform find $L^{-1}\left\{\frac{s}{(s^2+a^2)^2}\right\}$. (10)

2. a) Find $L^{-1}\left\{\frac{2s^2-4}{(s+1)(s-2)(s-3)}\right\}$. (10)

b) Solve by using Laplace transformation technique: $\frac{d^2y}{dt^2} - 6\frac{dy}{dt} + 9y = t^2e^{3t}$; subject to the condition $y(0) = 2, y'(0) = 6$. (12)

c) An inductor of 1 henry, a resistor of 6Ω and a capacitor of $1/9$ farad are connected in series with an e.m.f of E volts. At time $t = 0$, the charge on the capacitor and current in the circuit are zero. Find the charge and current at any time $t > 0$ if $E = \sin t$ volts. Draw the circuit also. (13)

3. a) Find the Fourier series for the function $f(t) = \pi - |t|$; $(-\pi \le t \le \pi)$, defined over a single period. (10)

b) Find the complex form of Fourier series for the function $g(t) = e^{-t}$; $(-1 < x < 1)$. (10)

c) An alternating current after passing through a rectifier, has the form (15)

$$I(x) = \begin{cases} I_0 \sin x, & 0 \le x \le \pi \\ 0, & \pi < x < 2\pi \end{cases}$$

Where I_0 is maximum current and the period is 2π. Determine the Fourier series exression of $I(x)$. Also sktech the graph of $I(x)$.

4. a) Find the Fourier transform of $F(x) = \begin{cases} 1-x^2, & |x| < 1 \\ 0, & |x| > 1 \end{cases}$, and hence evaluate $\int_0^\infty \frac{x\cos x - \sin x}{x^3}\cos\frac{x}{2}dx$ (15)

b) Find the Fourier sine transform of $g(x) = \begin{cases} x, & 0 < x < 1 \\ 2-x, & 1 < x < 2. \\ 0, & x > 2 \end{cases}$ (10)

c) Find the finite Fourier cosine transform of the function $F(x) = 2x;\ 0 < x < 4$. (10)

SECTION B

(Answer **ANY THREE** questions from this section in Script B)

5. a) Define with examples: (i) Square Matrix ; (ii) Skew-symmetric matrix ; (iii) Hermitian matrix; (iv) singular matrix (12)

   b) Matrix A and B are such that $3A - 2B = \begin{pmatrix} 2 & 1 \\ -2 & -1 \end{pmatrix}$ and $-4A + B = \begin{pmatrix} -1 & 2 \\ -4 & 3 \end{pmatrix}$. (10)

   c) When does a matrix have its inverse? If possible find the inverse of $\begin{bmatrix} 1 & 0 & 2 \\ 2 & -1 & 3 \\ 4 & 1 & 8 \end{bmatrix}$. (13)

6. a) Reduce the matrix A into its canonical form then to normal form and also find its rank where, $A = \begin{bmatrix} -4 & 1 & -6 \\ 1 & 2 & -5 \\ 6 & 3 & -4 \end{bmatrix}$. (12)

   b) Define Eigen value and Eigen vector. Find the Eigen values and Eigen vectors for the matrix: (15)

$$A = \begin{bmatrix} 2 & 2 & 1 \\ 1 & 3 & 1 \\ 1 & 2 & 2 \end{bmatrix}$$

   c) Discuss the consistency of the following system of equations: (08)

$$2x + 3y + 4z = 11$$
$$x + 5y + 7z = 15$$
$$3x + 11y + 13z = 25$$

7. a) Solve the following system of linear equations: (13)

$$x_1 + x_2 - x_3 - x_4 = -1$$
$$x_1 + x_2 + x_3 + x_4 = 3$$
$$x_1 - x_2 + x_3 - x_4 = 3$$
$$4x_1 + x_2 - 2x_3 + x_4 = 0$$

   , If Possible.

   b) Is $\vec{F} = (y^2 + 2xz^2 - 1)\hat{\imath} + 2xy\hat{\jmath} + 2xz^2\hat{k}$ irrotational? If so, find u such that $\vec{F} = grade\ u$. (12)

   c) In a three dimensional region, the temperature in a certain medium is given by $T = T_0(1 + ax + by)e^{cz}$, where a, b, c and $T_0(> 0)$ are constants. At the origin, find the direction along which the temperature changes most rapidly. (10)

8. a) If $\vec{A} = (3x^2 + 6y)\hat{\imath} - 14yz\hat{\jmath} - 20xz^2\hat{k}$, evaluate $\int_C \vec{A}d\vec{r}$ from (0,0,0) to (2,2,2) along the path C as $x = 2t, y = t^2, z = t^3$. (10)

   b) Evaluate $\oiint_S \vec{A}.\vec{n}ds$, where $\vec{A} = z\hat{\imath} + x\hat{\jmath} - 3y^2z\hat{k}$ and S is the surface of the cylinder $x^2 + y^2 = 16$ included in the first octant between z=0 and z=4. (13)

   c) Verify Green's theorem in the plane for $\oint_C [(xy + y^2)dx + x^2dy]$, where C is the closed curve of the region bounded by $y = x$ and $x^2 = y$. (12)