KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechatronics Engineering

B. Sc. Engineering 2nd Year 2nd Term Examination, 2020

EE 2231

(Signals and Linear Systems)

Time: 1 hr. 30 min Total Marks: 120

N.B.: i) Answer any TWO questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

SECTION-A

1(a) Find the energies of the pair of signal x(t) and y(t) in Fig. 1(a) and 1(b). Sketch and find the energy of signals x(t)+y(t) and x(t)−y(t). 12

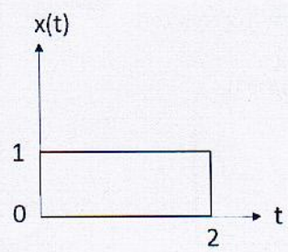


Fig. 1(a)

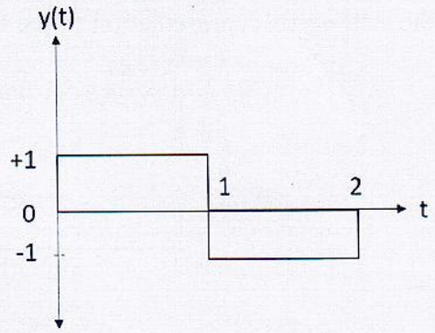


Fig. 1(b)

1(b) Explain energy and power signals. how to estimate them? 06

1(c) For the signal x(t) in Fig. 1(c), sketch: 12

(i) x(t−4)
(ii) x(t/1.5)
(iii) x(−t)
(iv) x(2t−4)
(v) x(2−t) and
(vi) x(5t)

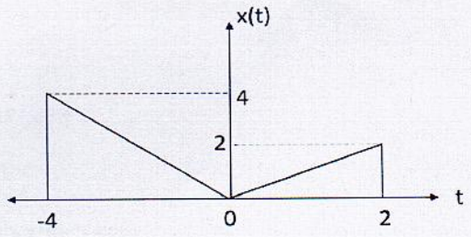


Fig. 1(c)

2(a) Sketch the following signal:$u(t-5)-u(t-7)$. 10

For the signal $x(t)=\begin{cases} t & 0\le t<1 \\ 0.5+0.5\cos(2\pi t) & 1\le t<2 \\ 3-t & 2\le t<3 \\ 0 & \text{otherwise} \end{cases}$

Find the energy.

2(b) For the systems described by the following expressions, with x(t) input and y(t) output, determine which are causal and which are non-causal. 10

(i) y(t) = x(t−2)
(ii) y(t) = x(−t)
(iii) y(t) = x(at); a>1
(iv) y(t) = x(at); a<1

2(c) Consider the signal x(t) in Fig. 2(c). Determine power and energy of v(t) where, $v(t)=3x(-(1/2)(t+1))$. Also draw v(t). 10

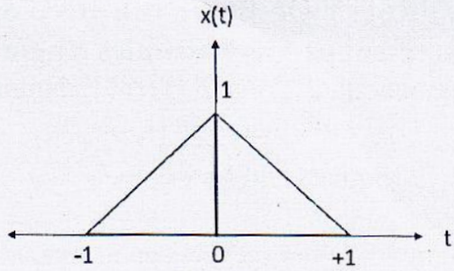


Fig. 2(c)

3(a) Determine the "forced response" of a system having transfer function, H(jω) and the input is $x(t) = 3.2\cos\omega t + 2.5\sin\omega t$; where the symbols have their usual meanings. 12

3(b) Obtain the state-space representation of the following system. 10

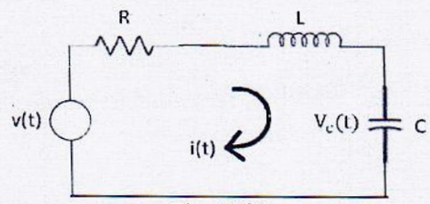


Fig. 3(b)

3(c) Draw the equivalent electrical system for the following mechanical system. 08

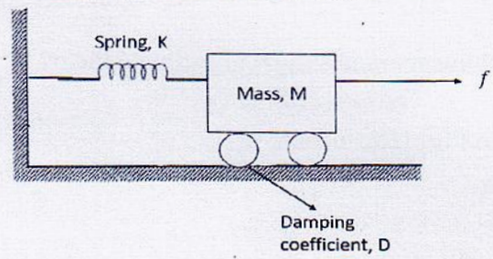


Fig. 3(c)

SECTION-B

4(a) Find the transfer function of the system $L\frac{dx(t)}{dy} + Rx(t) = y(t)$ where, x(t)=output and y(t)=input. 08

4(b) Find the Laplace transform of tu(t). 11

4(c) Derive the expression of the Fourier co-efficient a_n and b_n when, 11
$f_e\left(t \pm \frac{T}{2}\right) = f_e(t)$.

5(a) Describe the estimation process of the frequency spectrum of an aperiodic signal. 10
Show that the frequency spectrum of aperiodic signal is continuous.

5(b) Determine the response of the circuit shown in Fig. 5(b) to an applied single rectangular pulse of amplitude A and duration, T_p. 15

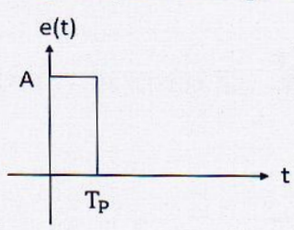
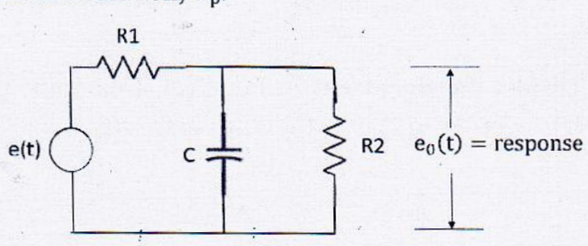


Fig. 5(b)



5(c) Explain the Gibbs phenomenon graphically. 05

6(a) Write down the differences between Fourier and Laplace transform. 04

6(b) Find the Laplace transform of the following function. 10

$$f(t) = 10e^{-0.3t}\cos(\alpha t + \theta)$$

6(c) A single half-sine cycle shown in below is applied to a series R-C combination. 16
Determine the voltage across the capacitor as a function of time.

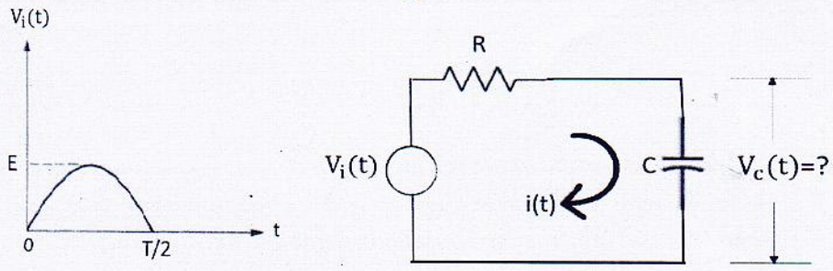


Fig. 6(c)

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KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechatronics Engineering

B. Sc. Engineering 2nd Year 2nd Term Examination, 2020

Math 2231

(Complex Variables and Harmonic Analysis)

Time: 1 hr. 30 min | Total Marks: 120

N.B.: i) Answer any TWO questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

SECTION-A

1(a) Find the roots and locate them graphically of $(-4+4i)^{1/5}$. 10

1(b) Define harmonic function. Prove that $u = x^2 - y^2 - 2xy - 2x + 3y$ is a harmonic function. Find v such that $f(z) = u + iv$ is analytic, where v is harmonic conjugate. 15

1(c) Prove that $\frac{d}{dz}(z^2\bar{z})$ does not exist anywhere. 05

2(a) Evaluate $\oint_c \frac{e^z}{(z^2+\pi^2)^2} dz$ where c is the circle $|z| = 4$. 15

2(b) State Taylor's theorem. Expand $f(z) = z^3 - 3z^2 + 4z - 2$ at $z = 2$ in a Taylor series. 15

3(a) Expand $f(z) = \frac{3z-3}{(z-1)(z-2)}$ in a Laurent series valid for (i) $|z| > 2$ and (ii) $1 < |z| < 2$ 15

3(b) Evaluate $\oint_c \frac{2z^2+5}{(z+2)^3(z^2+4)z^2} dz$, where c is the square with vertices at $1+i, 2+i, 2+2i$ and $1+2i$. 15

SECTION-B

4(a) Derive the recurrence equation and roots of the indicial equation to find series solution about $x = 0$ of the following differential equation: 15

$$2x^2y'' - xy' + (1-x^2)y = 0$$

4(b) Write Legendre's polynomial of degree n. Find $P_0(x), P_1(x), P_2(x)$ and $P_3(x)$. Also express $x^4 - 3x^2 + x$ in terms of Legendre's polynomials. 15

5(a) Derive the relation among $J_n(x), J_{n-1}(x)$ and $J_{n+1}(x)$ where, $J_n(x), J_{n-1}(x)$ and $J_{n+1}(x)$ are the Bessel's functions of order $n, n-1$ and $n+1$ respectively. 20

5(b) Prove that, $J_{-\frac{3}{2}}(x) = \sqrt{\frac{2}{\pi x}}\left(-\frac{\cos x}{x} - \sin x\right)$. 10

6. A rectangular plate with insulated surface is 8 cm wide and so long compared to its width that it may be considered infinite in length without introducing an appreciable error. If the temperature along one short edge $y = 0$ is given by $u(x, 0) = 100 \sin\left(\frac{\pi x}{8}\right); 0 < x < 8$ while the two long edges $x = 0$ and $x = 8$ as well as the other short edges are kept 0°C. Find the steady state temperature at any point of the plate. 30

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KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechatronics Engineering

B. Sc. Engineering 2nd Year 2nd Term Examination, 2020

ME 2231

(Thermodynamics and Heat Transfer)

Time: 1 hr. 30 min Total Marks: 120

N.B.: i) Answer any TWO questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

SECTION-A

1(a) How the properties of a system be categorized considering dependency on mass of that system? Explain with examples. 06

1(b) A person from Khalishpur, Khulna invented an engine and claimed that this engine requires no energy to produce work. Is it possible? Explain his invention with thermodynamics. 10

1(c) A piston-cylinder device operates 1 kg of fluid at 20×10^5 Pa pressure. The initial volume is 50 liter. The fluid is allowed to expand reversibly following a process $pV^{1.41} = \text{constant}$, so that the volume becomes double. The fluid is then cooled at constant pressure until the piston comes back to the original position. Keeping the piston unaltered, heat is added reversibly to restore it to initial pressure. Calculate the work done in the system. 14

2(a) Are efficiency and COP same? Explain. 07

2(b) Otto cycle is more efficient than diesel cycle for a particular compression ratio. Justify the statement. 08

2(c) Write SFEE. In a steady flow apparatus, 210 kJ of work is done by each kg of fluid. The specific volume of fluid, pressure, and velocity at the inlet are 0.43 m^3/kg, 7 bar, and 21 m/s. The inlet is 0.096 km above the floor, and the discharge pipe is at a height of 210 ft. The discharge conditions are 0.57 m^3/kg, 87 kPa, and 279 m/s. The total heat gain between the inlet and discharge is 17×10^3 J/kg of fluid. In flowing through this apparatus, does the specific internal energy increase or decrease, and by how much? 15

3(a) Why do binary vapor power cycle useful in power generation? Explain a typical binary vapor power cycle with neat sketch. 10

3(b) Briefly discuss the basic difference between the spark ignition engine and compression ignition engine. 08

3(c) Explain working principle of a water tube boiler with necessary sketch. 12

SECTION-B

4(a) Explain the physical meaning of thermal conductivity and thermal diffusivity. If material X have higher thermal conductivity and thermal diffusivity than material Y, how the heat transfer characteristic differ between the two materials? 08

4(b) Explain how the actual vapor compression refrigeration cycle differ from ideal vapor compression cycle with temperature-entropy diagram. 12

4(c) Why thermal comfort of human body is required? How human body can be compared with heat engine? What are the factors that affect thermal comfort? 10

5(a) How the free and forced convection differ? Explain the physical significance of Nusselt number. 08

5(b) What type of heat exchanger yields higher performance; parallel or counter? - Explain. 08

5(c) Air at $T_\infty = 20°C$ flow over plate surface of constant temperature $T_s = 170°C$, the dimensionless temperature profile represented as: 14

$$\frac{T(y) - T_\infty}{T_s - T_\infty} = e^{-ay}$$

Where a=3200 m^{-1} and y is the vertical distance from the plate surface. Determine the heat flux on the plate surface. Assume K=0.031 W/m.k

6(a) How the intensity of radiation is related to the emissive power? Explain. 10

6(b) Explain how the radiation from a real surface differ from blackbody and graybody? 08

6(c) Determine the wavelength at which the monochromatic emissive power of a tungsten filament at 1300K is a maximum. Also determine the maximum monochromatic emissive power at that wavelength. Furthermore, determine the monochromatic emissive power at 4μm. 12

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KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechatronics Engineering

B. Sc. Engineering 2nd Year 2nd Term Examination, 2020

MTE 2201

(Control Systems)

Time: 1 hr. 30 min | Total Marks: 120

N.B.: i) Answer any TWO questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

SECTION-A

1(a) Define a control system with example. Why control system is important in engineering? 07

1(b) For the following systems, argue in your opinion if it is open-loop or closed-loop. In the arguments, include definitions of the systems inputs and outputs. Describe how feedback is affected in the systems which is to be decided as closed-loop. 15

(i) Washing machine

(ii) Manual gear train in an automobile

1(c) Draw the control system design process. 08

2(a) Draw a typical transient response for a second order system and show the locations of all the transient response specification. 10

2(b) Find the time constant T_c, settling time T_s and rise time T_r of the given system, T(s). 10

$$T(s) = \frac{40}{s + 40}$$

2(c) Find the equivalent transfer function Y(s)/R(s) for the system shown in Fig. 2(c). 10

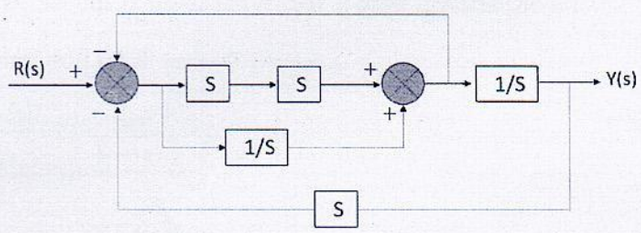

Fig. 2(c)

3(a) Define poles and zeros of a transfer function. What are the effects of location of poles and zeros on the stability of a system? 08

3(b) Find the poles and zeros of the system: 07

$$\frac{d^2y}{dt^2} + \frac{5dy}{dt} + 6y = \frac{5du}{dt}$$

3(c) The open-loop transfer function of a unity feedback system is $\frac{k}{s(1+0.4s)(1+0.25s)}$ 15

Find the restriction of k, so that the closed-loop system is absolutely stable.

SECTION-B

4(a) Define controllability, observability, detectability and stabilizability. 08

4(b) Convert the following state and output equations to a transfer function. 12

$$\dot{\underline{X}} = \begin{bmatrix} -4 & -2 \\ 4 & 0 \end{bmatrix} \underline{X} + \begin{bmatrix} 2 \\ 0 \end{bmatrix} u(t)$$

$$y = [2 \quad 1]\underline{X}$$

4(c) Represent the following transfer function to its state-space representation of parallel form. 10

$$\frac{C(s)}{R(s)} = \frac{24}{(s+2)(s+3)(s+4)}$$

5(a) Design an observed state feedback control system for the following regulator system. 22

$$\dot{\underline{X}} = \begin{bmatrix} 0 & 1 \\ 20 & 0 \end{bmatrix} \underline{X} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

$$y = [1 \quad 0]\underline{X}$$

Use pole placement approach to design the system. The desired closed-loop poles are $s = -2 \pm 4j$ for the controller. The observer is 4 times faster than the controller.

5(b) Draw the block diagram of the system found from Q.5(a) with observed state feedback. 08

6(a) State Cayley-Hamilton theorem. Prove the theorem for a system matrix, A. 10

$$A = \begin{bmatrix} 0 & 1 \\ -3 & -1 \end{bmatrix}$$

6(b) Design a PI controller for the feedback control system shown in Fig. 6(b). The performance criteria are settling time 2 sec. What is the response to the unit-step reference input? 14

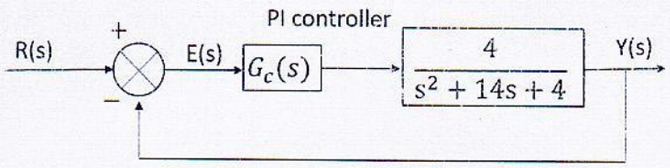

Fig. 6(b): PI controlled system

6(c) Define LQG and robust control. 06

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KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechatronics Engineering

B. Sc. Engineering 2nd Year 2nd Term Examination, 2020

MTE 2207

(Electro-Mechanical Systems)

Time: 1 hr. 30 min Total Marks: 120

N.B.: i) Answer any TWO questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

SECTION-A

1(a) Develop an expression of the generated voltage in series DC generator. Define critical field resistance. Why is the resistance of field winding of a DC machine kept below the critical field resistance? What is the function of commutator? 10

1(b) What are the effects of armature reaction in DC machines? How these effects can be minimized? 10

1(c) The induced emf in a DC machine while running at 750 rpm is 220V. 10
(i) Calculate the speed at which the induced emf will be 240V. Assume constant flux.
(ii) Also find the percentage increase in the field flux for an induced emf of 240V and speed of 700 rpm.

2(a) What is the significance of back emf of a DC motor? Using relevant diagrams and equations, explain the torque-speed characteristics of a DC shunt and series motor. 10

2(b) How can the speed of a DC motor be controlled above the base speed? Explain the Ward-Leonard system to control the speed of a DC motor. 10

2(c) A series motor has a resistance of 1Ω between its terminals. The motor runs at 800 rpm at 200V taking a current of 15A. Calculate the speed at which the motor will run when connected in series with a 5Ω resistance and taking the same current at the same supply voltage. 10

3(a) State some key points on the working procedure of a transformer. Derive the rms value of induced emf in the primary winding of a transformer. 10

3(b) Why transformer is rated in KVA instead of KW? Sketch the phasor diagram of a transformer operating at lagging and leading power factor. 10

3(c) Briefly explain open-circuit and short-circuit test of a transformer in order to measure core loss and Cu loss. 10

SECTION-B

4(a) Describe the working principle of an induction motor. Prove that, when a 3-ϕ induction motor is fed by 3-ϕ supply, a uniformly rotating magnetic flux of constant magnitude is produced. 10

4(b) Draw the equivalent circuit and power flow diagram of induction motor. A 50kW, 440V, 50Hz, 6 pole induction motor has a slip of 6% when operating at full-load conditions. At full-load conditions, the friction and windage losses are 300W, and the core losses are 600W. Find the following values for full-load conditions: 10

(i) The shaft speed η_m
(ii) The output power
(iii) The load torque τ_{load}
(iv) The induced torque τ_{ind}
(v) The rotor frequency

4(c) Explain the torque-speed characteristics of induction motor. Prove that, torque under running condition is maximum when rotor resistance equals slip multiplied by rotor reactance. 10

5(a) Why single-phase induction motor is not self-starting? Briefly explain the operation of permanent split capacitor motor. 10

5(b) State the difference between synchronous motor and induction motor. Draw the V-curve and inverse-V curve of synchronous motor. Describe the effect of increased load on synchronous motor under normal excitation. 10

5(c) What is breakaway torque? A 4-pole, 70kW, 3-ϕ, delta-connected, 60Hz, 440V cylindrical rotor synchronous motor runs at rated condition with 0.8pf lagging. The motor efficiency excluding field and stator losses, is 95% and X_s = 2.5Ω. Calculate: 10

(i) Maximum torque produced
(ii) Armature current
(iii) Back emf
(iv) Power angle and
(v) Mechanical power developed

6(a) Draw the block-diagram of servo motor. Explain how servo-mechanism precisely controls the position of motor shaft. 10

6(b) Describe the operation of stepper motor with neat sketch of relevant waveform. 10

6(c) State some key points on the construction of brushless DC motor. What are the major differences between conventional DC motor and brushless DC motor in terms of operational point of view? 10

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