Register Number:……………..

KUMARAGURU college of technology character is life

M.TECH DEGREE EXAMINATIONS: NOV/ DEC 2024

(Regulation 2024)

First Semester

DEFENCE TECHNOLOGY

24DTT501: Advanced Engineering Mathematics

COURSE OUTCOMES

CO1: Know the methods for solving differential equations, generating functions.

CO2: Understand basic concepts of Fourier Transform, Laplace Transforms and solve problems with periodic functions, step functions, impulse functions and convolution.

CO4: Understand the utilization of mathematical methods for solving problems having relevance to defence applications.

Time: Three Hours **Maximum Marks: 100**

PART A (4*20 = 80 Marks)

1.	a)	Scenario: A rocket engine's thrust response is modeled by the transfer function: $F(s) = \frac{20}{s(s+3)(s+5)}$ Find the inverse Laplace transform to determine the time-domain thrust response.	10	CO2	[K_2]
	b)	Scenario: The vibration of an aircraft component (e.g., wing) after it experiences an aerodynamic force is described by: $\frac{d^2y(t)}{dt^2} + 4\frac{dy(t)}{dt} + 13y(t) = f(t)$ where y(t) is the displacement, and f(t)=0 for the free vibration (unforced) case. Solve for y(t), the displacement of the component, using the Laplace transform and given initial conditions y(0)=2 and $\frac{dy(0)}{dt} = 0$.	10	CO4	[K_4]
2.	a)	A military bunker experiences an explosive shock wave, modeled by the equation: $M\frac{d^2u}{dt^2} + C\frac{du}{dt} + Ku = P_0e^{-\alpha t}$ where M=1000 kg, $C = 50$N·s/m, $K = 2000N/m$, $P_0 = 5000N$, and $\alpha = 0.2$. Find the displacement u(t) of the bunker over time.	10	CO4	[K_4]

b) A targeting system for a military vehicle uses feedback control, described by: 10 CO1 [K3]

$$\frac{d^2x}{dt^2} + 2\zeta\omega_n \frac{dx}{dt} + \omega_n^2 x = G(t),$$

where:

- x(t) is the position of the target,
- $\omega_n = 4$ rad/s is the natural frequency,
- $\zeta = 0.5$ is the damping ratio,
- $G(t) = 5\cos(t)$ N is a feedback gain.

1. Solve the homogeneous equation for the system.
2. Use the variation of parameters method to find a particular solution.

3. a) A jammer emits a signal with the frequency spectrum: $F(\omega) = \text{rect}(\frac{\omega}{2\pi})$. Determine the corresponding time-domain signal to understand its effect on communication systems. 10 CO4 [K4]

b) A radar system sends out a short pulse modeled by the function $p(t) = sinc(t)$. Find its Fourier Transform to determine the frequency spectrum and bandwidth. 10 CO4 [K4]

4. a) The noise from an aircraft propeller is modeled as a periodic step function: 10 CO2 [K2]

$$f(x) = \begin{cases} 1, & 0 \leq x < \pi, \\ -1, & \pi \leq x < 2\pi. \end{cases}$$

Find the Fourier series for $f(x)$ over (0,2π) to identify noise harmonics and develop noise-canceling systems.

b) The temperature of a tank's armor under cyclic thermal stress is given by: 10 CO2 [K_3]

$$f(x) = x^2 - L^2, x \in (-L, L).$$

Find the Fourier series of f(x) to study the distribution of stress and predict failure points.

Answer any ONE Question

PART B (1*20 = 20 Marks)

5. a) In electronic warfare, a jamming signal is used to disrupt the communication of enemy equipment. Suppose the jamming signal is a periodic sinusoidal wave given by: 10 CO4 [K_4]

$f(t) = A\sin(\omega t)$ where A is the amplitude and ω is the angular frequency.

Find the Laplace transform of the jamming signal, considering it as a periodic function with period $T = \frac{2\pi}{\omega}$.

b) The vibrations in a tank's engine can be modeled as a damped sinusoidal function: $f(t) = e^{-\alpha t}\cos(\omega_0 t)$ Calculate its frequency spectrum to identify resonance frequencies that may impact performance. 10 CO4 [K_3]

OR

6. a) The barrel of a gun experiences periodic heating during firing, with heat flux modeled by: 10 CO2 [K_3]

$$f(x) = \begin{cases} H, & 0 \le x \le L, \\ 0, & L < x \le 2L. \end{cases}$$

where H is the heat intensity. Find the Fourier series for f(x) over $(0,2L)$ to model heat distribution

b)	Sonar systems onboard submarines rely on wave propagation characteristics analyzed using eigenvalues and eigenvectors of the propagation matrix :	10	CO1	[K_2]

$P = \begin{bmatrix} 5 & 1 & 0 \\ 1 & 4 & 1 \\ 0 & 1 & 3 \end{bmatrix}$ Find the eigenvalues and eigenvectors of P.

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