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32 YEARS SOLUTION

COMPLETE SOLUTIONS WITH EXPLANATIONS | THOROUGHLY REVISED AND UPDATED

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1987-2018

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PREFACE

Engineering Services Exam (ESE) is one of most coveted exams written by engineering students aspiring for reputed posts in the various departments of the Government of India. ESE is conducted by the Union Public Services Commission (UPSC), and therefore the standards to clear this exam too are very high. To clear the ESE, a candidate needs to clear three stages - ESE Prelims, ESE Mains and Personality Test.

It is not mere hard work that helps a student succeed in an examination like ESE that witnesses lakhs of aspirants competing neck to neck to move one step closer to their dream job. It is hard work along with smart work that allows an ESE aspirant to fulfil his dream.

After detailed interaction with students preparing for ESE, IES Master has come up with this book which is a one-stop solution for engineering students aspiring to crack this most prestigious engineering exam. The book includes previous years' solved conventional questions segregated topicwise along with detailed explanation. This book will also help ESE aspirants get an idea about the pattern and weightage of questions asked in ESE.

IES Master feels immense pride in bringing out this book with utmost care to build upon the exam preparedness of a student up to the UPSC standards. The credit for flawless preparation of this book goes to the entire team of IES Master Publication. Teachers, students, and professional engineers are welcome to share their suggestions to make this book more valuable.

IES Master Publication
New Delhi

CONTENTS

UNIT 1

CIRCUIT THEORY

SYLLABUS

Circuits elements. Kirchoff's Laws. Mesh and nodal analysis. Network Theorems and applications. Natural response and forced response. Transient response and steady state response for arbitrary inputs. Properties of networks in terms of poles and zeros. Transfer function. Resonant circuits. Three-phase circuits. Two-port networks. Elements of two-element network synthesis.

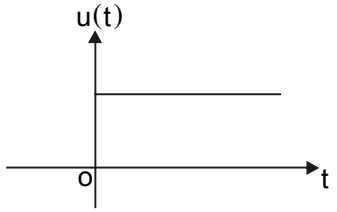
CONTENTS

1 Network Elements

Q–1: ***Define precisely unit step and unit impulse functions.*** **[8 Marks ESE–1987]**

Sol. **Unit Step Function:** Unit step function is defined as

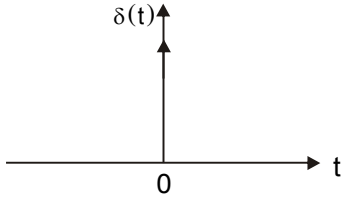
$$u(t) = \begin{cases} 0 & ; \quad t < 0 \\ 1 & ; \quad t > 0 \end{cases}$$



Note : Unit step function is discontinuous at t = 0

Unit impulse function: Unit impulse function is defined as

$$\delta(t) = \begin{cases} 0 & ; \quad t \neq 0 \\ \infty & ; \quad t = 0 \end{cases}$$



Note : The area of the unit impulse signal is 1

$$\int_{-\infty}^{\infty} \delta(t)dt = 1$$

The continuous-time unit step is the running integral of the unit impulse

$$u(t) = \int_{-\infty}^{t} \delta(\tau)d\tau$$

$$\Rightarrow \qquad \delta(t) = \frac{du(t)}{dt}$$

i.e. unit impulse is the running derivative of the unit step function.

Q–2: ***Sketch the following function from t = 0 to t = 10 units, indicating all salient values at different times***

$$50(1-\frac{1}{2}t[u(t)-u(t-4)]$$ **[12 Marks ESE–1987]**

Sol.

$$f(t) = 50\left[1-\frac{1}{2}t\{u(t)-u(t-4)\}\right]$$

$$= 50-25t\{u(t)-u(t-4)\}$$

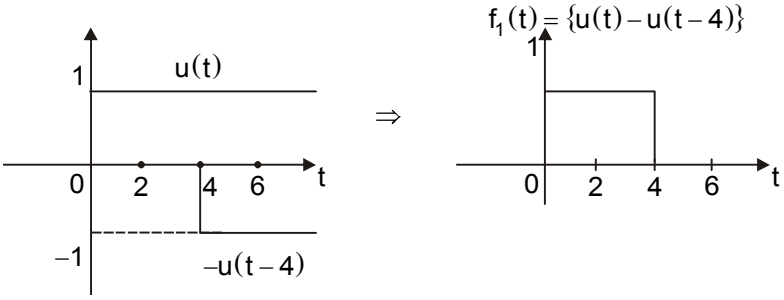
The graphs of function at different stages are shown below.

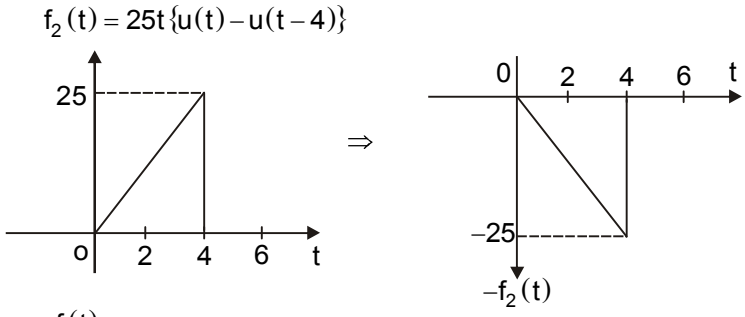
Let

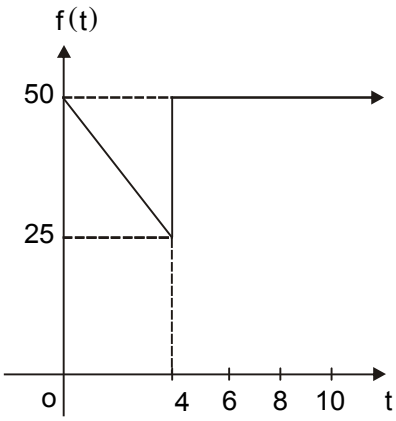
$$f_1(t) = u(t)-u(t-4)$$

$$f_2(t) = 25t\{u(t)-u(t-u)\}$$

$$\therefore \quad f(t) = 50-f_2(t)$$



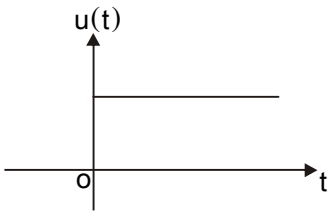




Q–3: Unit Step and Unit Impulse Functions. **[3 Marks ESE–1989]**

Sol. **Unit Step Function:** Unit step function is defined as

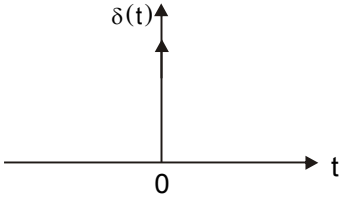
$$u(t) = \begin{cases} 0 & ; \quad t<0 \\ 1 & ; \quad t>0 \end{cases}$$



Note : Unit step function is discontinuous at t = 0

Unit impulse function: Unit impulse function is defined as

$$\delta(t) = \begin{cases} 0 & ; \ t \neq 0 \\ \infty & ; \ t = 0 \end{cases}$$



Note : The area of the unit impulse signal is 1

$$\int_{-\infty}^{\infty} \delta(t)dt = 1$$

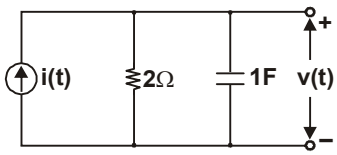
The continuous-time unit step is the running integral of the unit impulse

$$u(t) = \int_{-\infty}^{t} \delta(\tau)d\tau$$

$$\Rightarrow \qquad \delta(t) = \frac{du(t)}{dt}$$

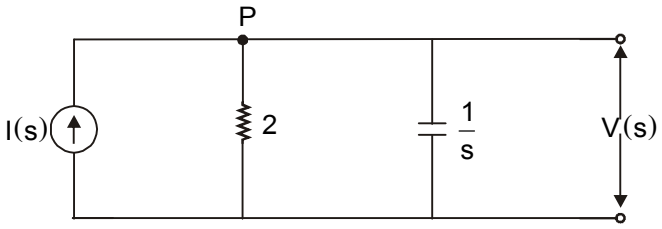
i.e. Unit impulse is the running derivative of the Unit Step Function.

Q–4: ***Considering i(t) as input and v(t) as output in the network shown in Fig., find unit step response and the unit ramp response with v(0) = 0.***



[12 Marks ESE–1989]

Sol.



Applying KCL at node P $\qquad I(s) = \dfrac{V(s)}{2} + \dfrac{V(s)}{1/s} = V(s)[s+0.5]$

$$\Rightarrow \qquad V(s) = \frac{I(s)}{(s+0.5)}$$

For unit step input curren $\qquad I(s) = \dfrac{1}{s}$

$$\Rightarrow \qquad V(s) = \frac{1}{s(s+0.5)} = 2\left[\frac{1}{s} - \frac{1}{s+0.5}\right]$$

Taking inverse a laplace $\qquad v(t) = \mathcal{L}^{-1}[V(s)] = 2[1-e^{-0.5t}]u(t)$

For unit ramp input current $\qquad I(s) = \dfrac{1}{s^2}$

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