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2. Question Paper & Answer keys
ANALYSIS OF GATE 2012
Electronics and Communication Engineering

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- Network Theory: 13%
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## GATE-2012- ECE

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GATE 2012 Examination
Electronics and Communication Engineering

Q.1 - Q.25 Carry One Mark each.

1. The current $i_b$ through the base of a silicon npn transistor is $1 + 0.1 \cos(10000 \pi t)$ mA. At 300 K, the $r_i$ in the small signal model of the transistor is [Ans. C]

2. The power spectral density of a real process $X(t)$ for positive frequencies is shown below. The values of $E[X^2(t)]$ and $E[X(t)]$, respectively, are [Ans. B]

3. In a baseband communications link, frequencies upto 3500 Hz are used for signaling. Using a raised cosine pulse with 75% excess bandwidth and for no inter-symbol interference, the maximum possible signaling rate in symbols per second is [Ans. C]

4. A plane wave propagating in air with $E = (8\hat{a}_x + 6\hat{a}_y + 5\hat{a}_z)e^{(\omega t + 3x - 4y)}V/m$ is incident on perfectly conducting slab positioned at $x \leq 0$. The $E$ field of the reflected wave is [Ans. C]
5. The electric field of a uniform plane electromagnetic wave in free space, along the positive x direction, is given by \( \vec{E} = 10(\hat{a}_y + j\hat{a}_z)e^{-j\omega x} \). The frequency and polarization of the wave, respectively, are:

(A) 1.2 GHz and left circular
(B) 4 Hz and left circular

[Ans. A]

6. Consider the given circuit

\[ \text{In this circuit, the race around} \]

(A) Does not occur
(B) Occurs when \( \text{CLK} = 0 \)
(C) Occurs when \( \text{CLK} = 1 \) and \( A = B = 1 \)
(D) Occurs when \( \text{clk} = 1 \) and \( A = B = 0 \)

[Ans. A]

7. The output \( Y \) of a 2-bit comparator is logic 1 whenever the 2-bit input \( A \) is greater than the 2-bit input \( B \).

The number of combinations for which the output is logic 1, is

(A) 4
(B) 6
(C) 8
(D) 10

[Ans. B]

8. The I-V characteristics of the diode in the circuit given below are:

\[ i = \begin{cases} v - 0.7 & \text{if } v \geq 0.7 \text{ V} \\ 500 & \text{if } v < 0.7 \text{ V} \end{cases} \]

The current in the circuit is

(A) 10 mA
(B) 9.3 mA
(C) 6.67 mA
(D) 6.2 mA

[Ans. D]
9. In the following figure, $C_1$ and $C_2$ are ideal capacitors. $C_1$ has been charged to 12 V before the ideal switch $S$ is closed at $t = 0$. The current $i(t)$ for all $t$ is.

(A) Zero  
(B) a step function  
(C) an exponentially decaying function  
(D) an impulse function  
[Ans. D]

10. The average power delivered to an impedance $4-j3 \Omega$ by a current $5\cos (100\pi t+100)$ A is

(A) 44.2 W  
(B) 50 W  
(C) 62.5 W  
(D) 125 W  
[Ans. B]

11. The unilateral Laplace transform of $f(t)$ is $\frac{1}{s^2+s+1}$. The unilateral Laplace transform of $tf(t)$ is

(A) $-\frac{s}{(s^2+s+1)^2}$  
(B) $-\frac{2s+1}{(s^2+s+1)^2}$  
(C) $\frac{s}{(s^2+s+1)^2}$  
(D) $\frac{2s+1}{(s^2+s+1)^2}$  
[Ans. D]

12. With initial condition $x(1) = 0.5$, the solution of the differential equation, $t\frac{dx}{dt} + x = t$ is

(A) $x = t - \frac{1}{2}$  
(B) $x = t^2 - \frac{1}{2}$  
(C) $xt = \frac{t^2}{2}$  
(D) $x = \frac{t}{2}$  
[Ans. C]

13. The diodes and capacitors in the circuit shown are ideal. The voltage $v(t)$ across the diode $D_1$ is

(A) $\cos(\omega t) - 1$  
(B) $\sin(\omega t)$  
(C) $1 - \cos(\omega t)$  
(D) $1 - \sin(\omega t)$  
[Ans. A]
14. In the circuit shown

\[ 5 \text{ Volts} \]

\[ A \quad \overline{B} \quad C \]
\[ B \quad (A + B) \quad C \]
\[ A \quad B \quad \overline{C} \]

(A) \( Y = \overline{A} \overline{B} + \overline{C} \)  
(B) \( Y = (A + B)C \)  
(C) \( Y = (A + B)\overline{C} \)  
(D) \( Y = AB + C \)  
[Ans. A]

15. A source alphabet consists of \( N \) symbols with the probability of the first two symbols being the same. A source encoder increases the probability of the first symbol by a small amount \( \varepsilon \) and decreases that of the second by \( \varepsilon \). After encoding, the entropy of the source

(A) Increases  
(B) Remains the same  
(C) Increases only if \( N = 2 \)  
(D) Decreases  
[Ans. D]

16. A coaxial cable with an inner diameter of 1 mm and outer diameter of 2.4 mm is filled with a dielectric of relative permittivity 10.89. Given

\[ \mu_0 = 4\pi \times 10^{-7} \text{ H/m}, \quad \varepsilon_0 = \frac{10^{-9}}{36} \text{ F/m} \]

the characteristic impedance of the cable is

(A) 330 \( \Omega \)  
(B) 100 \( \Omega \)  
(C) 143.3 \( \Omega \)  
(D) 43.4 \( \Omega \)  
[Ans. *] Not Matching for IIT Key

17. The radiation pattern of an antenna in spherical co-ordinates is given by

\[ F(\theta) = \cos \theta; \quad 0 \leq \theta \leq \pi/2 \]

The directivity of the antenna is

(A) 10 dB  
(B) 12.6 dB  
(C) 11.5 dB  
(D) 18 dB  
[Ans. A]

18. If \( x[n] = (1/3)^{|n|} - (1/2)^{|n|} u[n] \), then the region of convergence (ROC) of its Z-transform in the Z-plane will be

(A) \( \frac{1}{3} < |Z| < 3 \)  
(B) \( \frac{1}{3} < |Z| < \frac{1}{2} \)  
(C) \( \frac{1}{2} < |Z| < 3 \)  
(D) \( \frac{1}{3} < |Z| \)  
[Ans. C]
19. In the sum of products function \( f(X, Y, Z) = \Sigma(2, 3, 4, 5) \), the prime implicants are
   (A) \( XY, XY \)  \( \uparrow \)  \( \uparrow \)
   (B) \( XY, XYZ, XYZ \)
   (C) \( XYZ, XYZ, XYZ \)
   (D) \( XYZ, XYZ, XYZ, XYZ \)
   [Ans. A]

20. A system with transfer function
   \[
   G(s) = \frac{(s^2 + 9)(s + 2)}{(s + 1)(s + 3)(s + 4)}
   \]
   is excited by \( \sin(\omega t) \). The steady-state output of the system is zero at
   (A) \( \omega = 1 \text{ rad/s} \)
   (B) \( \omega = 2 \text{ rad/s} \)
   (C) \( \omega = 3 \text{ rad/s} \)
   (D) \( \omega = 4 \text{ rad/s} \)
   [Ans. A]

21. The impedance looking into nodes 1 and 2 in the given circuit is
   \[
   \begin{array}{c}
   \text{(A) } 50 \Omega \\
   \text{(B) } 100 \Omega \\
   \text{(C) } 5k\Omega \\
   \text{(D) } 10.1k\Omega
   \end{array}
   \]
   [Ans. A]

22. In the circuit shown below, the current through the inductor is
   \[
   \begin{array}{c}
   \text{(A) } \frac{2}{1+j} \text{ A} \\
   \text{(B) } \frac{1}{1+j} \text{ A} \\
   \text{(C) } \frac{-1}{1+j} \text{ A} \\
   \text{(D) } 0 \text{ A}
   \end{array}
   \]
   [Ans. \(-30\)]

23. Given \( f(z) = \frac{1}{z+1} - \frac{2}{z+3} \). If \( C \) is a counterclockwise path in the \( z \)-plane such that \( |z+1| = 1 \), the value of \( \oint_C f(z) \text{dz} \) is
   (A) \(-2\)  \( \uparrow \)
   (B) \(-1\)
   (C) \(1\)
   (D) \(2\)
   [Ans. C]
24. Two independent random variables X and Y are uniformly distributed in the interval [1, 1].
The probability that max [X, Y] is less than 1/2 is
(A) 3/4  (C) 1/4
(B) 9/16  (D) 2/3
[Ans. B]

25. If x = \sqrt{-1}, then the value of x^8 is
(A) e^{-\pi/2}  (C) x
(B) e^{\pi/2}  (D) 1
[Ans. A]

26. The source of a silicon (n_i = 10^{10} per cm^3) n-channel MOS transistor has an area of
1 squm and a depth of 1μm. If the dopant density in the source is 10^{19}/cm^3, the number of
holes in the source region with the above volume is approximately
(A) 10^7  (C) 10
(B) 100  (D) 0
[Ans. D]

27. A BPSK scheme operating over an AWGN channel with noise power spectral density of N_0/2,
uses equiprobable signals s_1(t) = \sqrt{2E/\pi} \sin(\omega_0 t) and
s_2(t) = -\sqrt{2E/\pi} \sin(\omega_0 t)
over the symbol interval, (0, T). If the local oscillator in a coherent receiver is ahead in phase
by 45° with respect to the received signal, the probability of error in the resulting system is
(A) Q\left(\frac{2E}{N_0}\right)  (C) Q\left(\frac{E}{2N_0}\right)
(B) Q\left(\frac{E}{\sqrt{N_0}}\right)  (D) Q\left(\frac{E}{\sqrt{4N_0}}\right)
[Ans. B]

28. A transmission line with a characteristic impedance of 100 Ω is used to match a 50 Ω section to
a 200 Ω section. If the matching is to be done both at 429 MHz and 1 GHz, the length of the
transmission line can be approximately
(A) 82.5 cm  (C) 1.85 m
(B) 1.58m  (D) 1.75 m
[Ans. B]

29. The input x(t) and output y(t) of a system are related as y(t) = \int_{-\infty}^{t} x(\tau) \cos(3\tau) d\tau. The system is
(A) time-invariant and stable  (C) time-invariant and not stable
(B) stable and not time-invariant  (D) not time-invariant and not stable
[Ans. D]
30. The Feedback system shown below oscillates at 2 rad/s when

\[
\frac{Y(s)}{R(s)} = \frac{K(s + 1)}{(s^3 + a s^2 + 2 s + 1)}
\]

(A) K=2 and a=0.75  
(B) K=3 and a=0.75  
(C) K=4 and a=0.5  
(D) K=2 and a=0.5  
[Ans. A]

31. The Fourier transform of a signal \( h(t) \) is

\[
H(j\omega) = \frac{2 \cos(\omega) (\sin(\omega))}{\omega}
\]

The value of \( h(0) \) is

(A) \( \frac{1}{4} \)  
(B) \( \frac{1}{2} \)  
(C) \( 1 \)  
(D) \( 2 \)  
[Ans. C]

32. The state variable description of an LTI system is given by

\[
\begin{bmatrix}
\dot{x}_1 \\
\dot{x}_2 \\
\dot{x}_3 \\
\end{bmatrix} =
\begin{bmatrix}
0 & a_1 & 0 \\
0 & 0 & a_2 \\
a_3 & 0 & 0 \\
\end{bmatrix}
\begin{bmatrix}
x_1 \\
x_2 \\
x_3 \\
\end{bmatrix} +
\begin{bmatrix}
0 \\
0 \\
1 \\
\end{bmatrix} u
\]

\( y = [1 \ 0 \ 0] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} \)

Where \( y \) is the output and \( u \) is the input. The system is controllable for

(A) \( a_1 \neq 0, a_2 = 0, a_3 \neq 0 \)  
(B) \( a_1 = 0, a_2 \neq 0, a_3 \neq 0 \)  
(C) \( a_1 = 0, a_2 \neq 0, a_3 = 0 \)  
(D) \( a_1 \neq 0, a_2 \neq 0, a_3 = 0 \)  
[Ans. D]

33. Assuming both the voltage sources are in phase the value of \( R \) for which maximum power is transferred from circuit A to circuit B is

(A) \( 0.8 \Omega \)  
(B) \( 1.4 \Omega \)  
(C) \( 2 \Omega \)  
(D) \( 2.8 \Omega \)  
[Ans. A]

34. Consider the differential equation

\[
\frac{d^2 y(t)}{dt^2} + 2 \frac{dy(t)}{dt} + y(t) = \delta(t) \text{ with }
\]

\( y(t)|_{t=0^-} = -2 \) and \( \frac{dy}{dt}|_{t=0^-} = 0 \).

The numerical value of \( \frac{dy}{dt}|_{t=0^+} \) is

(A) \( -2 \)  
(B) \( -1 \)  
(C) \( 0 \)  
(D) \( 1 \)  
[Ans. D]
35. The direction of vector $A$ is radially outward from the origin, with $|A| = K r^n$ where $r^2 = x^2 + y^2 + z^2$ and $K$ is constant. The value of $n$ for which $\nabla \cdot A = 0$ is
   (A) $-2$  (B) $2$  (C) $1$  (D) $0$
   [Ans. A]

36. A fair coin is tossed till a head appears for the first time probability that the number of required tosses is odd, is
   (A) $1/3$  (B) $1/2$  (C) $2/3$  (D) $3/4$
   [Ans. C]

37. In the CMOS circuit shown, electron and hole mobilities are equal, and $M_1$ and $M_2$ are equally sized. The device $M_1$ is in the linear region if
   
   ![CMOS circuit diagram]

   (A) $V_{in} < 1.875$ V  (B) $1.875$ V $< V_{in} < 3.125$ V  (C) $V_{in} > 3.125$ V  (D) $0 < V_{in} < 5$ V
   [Ans. A]

38. A binary symmetric channel (BSC) has a transition probability of $1/8$. If the binary transmit symbol $X$ is such that $P(X = 0) = 9/10$, then the probability of error for an optimum receiver will be
   (A) $7/80$  (B) $63/80$  (C) $9/10$  (D) $1/10$
   [Ans. D]

39. The signal $m(t)$ as shown is applied both to a phase modulator (with $k_p$ as the phase constant) and a frequency modulator (with $k_f$ as the frequency constant) having the same carrier frequency.

   ![Signal m(t)]

   The ratio $k_p/k_f$ (in rad/Hz) for the same maximum phase deviation is
   (A) $8 \pi$  (B) $4 \pi$  (C) $2 \pi$  (D) $\pi$
   [Ans. B]
40. The magnetic field along the propagation direction inside a rectangular waveguide with the cross-section shown in the figure is
\[ H_z = 3 \cos(2.094 \times 10^2 x) \cos(2.618 \times 10^2 y) \cos(6.283 \times 10^1 t - \beta z) \]

The phase velocity \( v_p \) of the wave inside the waveguide satisfies
(A) \( v_p > c \)  
(B) \( v_p = c \)  
(C) \( 0 < v_p < c \)  
(D) \( v_p = 0 \)
[Ans. D]

41. The circuit shown is a

(A) Low pass filter with \( f_{3dB} = \frac{1}{(R_1 + R_2)C} \) rad/s
(B) High pass filter with \( f_{3dB} = \frac{1}{R_1 C} \) rad/s
(C) Low pass filter with \( f_{3dB} = \frac{1}{R_1 C} \) rad/s
(D) High pass filter with \( f_{3dB} = \frac{1}{(R_1 + R_2)C} \) rad/s
[Ans. B]

42. Let \( y[n] \) denote the convolution of \( h[n] \) and \( g[n] \), where \( h[n] = (1/2)^n u[n] \) and \( g[n] \) is causal sequence. If \( y[0] = 1 \) and \( y[1] = 1/2 \), then \( g[1] \) equals
(A) 0  
(B) 1/2  
(C) 1  
(D) 3/2
[Ans. A]

43. The state transition diagram for the logic circuit shown is
44. The voltage gain $A_v$ of the circuit shown below is

<table>
<thead>
<tr>
<th>Answer</th>
<th>Value</th>
</tr>
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<tr>
<td>(A)</td>
<td>13.7V</td>
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45. If $V_A - V_B = 6$ V, then $V_C - V_D$ is

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<th>Value</th>
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<tr>
<td>(A)</td>
<td>5V</td>
</tr>
<tr>
<td>(B)</td>
<td>2V</td>
</tr>
<tr>
<td>(C)</td>
<td>3V</td>
</tr>
<tr>
<td>(D)</td>
<td>6V</td>
</tr>
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46. The maximum value of

$$f(x) = x^3 - 9x^2 + 24x + 5$$

in the interval $[1,6]$ is

<table>
<thead>
<tr>
<th>Answer</th>
<th>Value</th>
</tr>
</thead>
<tbody>
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<td>(A)</td>
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<td>(B)</td>
<td>25</td>
</tr>
<tr>
<td>(C)</td>
<td>41</td>
</tr>
<tr>
<td>(D)</td>
<td>46</td>
</tr>
</tbody>
</table>
47. Given that \( A = \begin{bmatrix} 5 & 3 \\ 2 & 1 \end{bmatrix} \) and \( I = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \), the value of \( A^3 \) is
   (A) \( 15A + 12I \)  
   (B) \( 19A + 30 \)  
   (C) \( 17A + 15I \)  
   (D) \( 17A + 21 \)
   [Ans. B]

Common Data for Questions 48 and 48
With 10 V dc connected at port A in the linear nonreciprocal two-port network shown below, the following were observed:
(i) \( 1 \Omega \) connected at port B draws a current of 3 A
(ii) \( 2.5 \Omega \) connected at port B draws a current of 2 A

48. With 10 V dc connected at port A, the current drawn by \( 7 \Omega \) connected at port B is
   (A) \( \frac{3}{7} \) A  
   (B) \( \frac{5}{7} \) A  
   (C) \( 1 \) A  
   (D) \( \frac{9}{7} \) A
   [Ans. C]

49. For the same network, with 6 V dc connected at port A, \( 1 \Omega \) connected at port B draws \( \frac{7}{3} \) A. If 8 V dc is connected to port A, the open circuit voltage at port B is
   (A) \( 6 \) V  
   (B) \( 7 \) V  
   (C) \( 8 \) V  
   (D) \( 9 \) V
   [Ans. B]

Common Data for Questions 50 and 51
In the three dimensional view of a silicon n-channel MOS transistor shown below, \( \delta = 20 \) nm. The transistor is of width \( 1 \) \( \mu \)m. The depletion width formed at every p-n junction, is 10nm. The relative permittivities of Si and SiO\(_2\), respectively, are 11.7 and 3.9, and \( \varepsilon_0 = 8.9 \times 10^{-12} \) F/m.

50. The gate-source overlap capacitance is approximately
   (A) \( 0.7 \) fF  
   (B) \( 0.7 \) pF  
   (C) \( 0.35 \) fF  
   (D) \( 0.24 \) pF
   [Ans. A]

51. The source-body junction capacitance is approximately
   (A) \( 2 \) fF  
   (B) \( 7 \) fF  
   (C) \( 2 \) pF  
   (D) \( 7 \) pF
   [Ans. A]
Statement for Linked Answer Questions 52 and 53
An infinitely long uniform solid wire of radius \(a\) carries a uniform dc current of density \(J\).

52. The magnetic field at a distance \(r\) from the center of the wire is proportional to
(A) \(r\) for \(r < a\) and \(1/r^2\) for \(r > a\)
(B) 0 for \(r < a\) and \(1/r\) for \(r > a\)
(C) \(r\) for \(r < a\) and \(1/r\) for \(r > a\)
(D) 0 for \(r < a\) and \(1/r^2\) for \(r > a\)
[Ans. C]

53. A hole of radius \(b\) (\(b < a\)) is now drilled along the length of the wire at a distance \(d\) from the center of the wire as shown below.

The magnetic field inside the hole is
(A) uniform and depends only on \(d\)
(B) uniform and depends on both \(b\) and \(d\)
(C) uniform and depends on both \(b\) and \(d\)
(D) non uniform
[Ans. C]

Statement for Linked Answer Questions 54 and 55
The transfer function of a compensator is given as
\[ G_c(s) = \frac{s + a}{s + b} \]

54. \(G_c(s)\) is a lead compensator if
(A) \(A = 1, b = 2\)
(B) \(A = 3, b = 2\)
(C) \(A = -3, b = -1\)
(D) \(A = 3, b = 1\)
[Ans. A]

55. The phase of the above lead compensator is maximum at
(A) \(\sqrt{2}\) rad/s
(B) \(\sqrt{3}\) rad/s
(C) \(\sqrt{3}\) rad/s
(D) \(1/\sqrt{3}\) rad/s
[Ans. A]

General Aptitude One Marks Question Q. 56 to Q. 60
56. One of the parts (A, B, C, D) in the sentence given below contains an ERROR. Which one of the following is INCORRECT?
I requested that he should be given the driving test today instead of tomorrow
(A) Requested that
(B) Should be given
(C) The driving test
(D) Instead of-tomorrow
[Ans. B]

57. If \((1.001)^{1259} = 3.52\) and \((1.001)^{2062} = 7.85\), then \((1.001)^{3321} =
(E) 2.23
(F) 4.33
(G) 11.37
(H) 27.64
[Ans. D]
58. Choose the most appropriate alternative from the options given below to complete the following sentence:
If the tired soldier wanted to lie down, he ______ the mattress out on the balcony.
(A) Should take  (B) Shall take  (C) Should have taken  (D) Will have taken
[Ans. A]

59. Choose the most appropriate word from the options given below to complete the following sentence:
Given the seriousness of the situation that he had to face, his ____ was impressive.
(A) beggary  (B) nomenclature  (C) jealousy  (D) nonchalance
[Ans. D]

60. Which one of the following options is the closest in meaning to the word given below?
Latitude
(A) Eligibility  (B) Freedom  (C) Coercion  (D) Meticulousness
[Ans. B]

General Aptitude Two Marks Question Q. 61 to Q. 65

61. A and B are friends. They decide to meet between 1 PM and 2 PM on a given day. There is a condition that whoever arrives first will not wait for the other for more than 15 minutes. The probability that they will meet on that day is
(A) 1/4  (B) 1/16  (C) 7/16  (D) 9/16
[Ans. A]

62. One of the legacies of the Roman legions was discipline. In the legions, military law prevailed and discipline was brutal. Discipline on the battlefield kept units obedient, intact and fighting even when the odds and conditions were against them.
Which one of the following statements best sums up the meaning of the above passage?
(A) Thorough regimentation was the main reason for the efficiency of the Roman legions even in adverse circumstances
(B) The legions were treated inhumanly as if the men were animals
(C) Discipline was the armies' inheritance from their seniors
(D) The harsh discipline to which the legions were subjected to led to the odds and conditions being…… against them
[Ans. A]

63. Raju has 14 currency notes in his pocket consisting of only □ 20 notes and □ 10 notes. The total money value of the notes is □ 230. The number of □ 10 notes that Raju has is
(A) 5  (B) 6  (C) 9  (D) 10
[Ans. A]
64. There are eight bags of rice looking alike, seven of which have equal weight and one is slightly heavier. The weighing balance is of unlimited capacity. Using this balance, the minimum number of weighing’s required to identify the heavier bag is

(A) 2
(B) 3
(C) 4
(D) 8

[Ans. A]

65. The data given in the following table summarizes the monthly budget of an average household.

<table>
<thead>
<tr>
<th>Category</th>
<th>Amount (₹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td>4000</td>
</tr>
<tr>
<td>Clothing</td>
<td>1200</td>
</tr>
<tr>
<td>Rent</td>
<td>2000</td>
</tr>
<tr>
<td>Savings</td>
<td>1500</td>
</tr>
<tr>
<td>Other expenses</td>
<td>1800</td>
</tr>
</tbody>
</table>

The approximate percentage of the monthly budget NOT spent on savings is

(A) 10%
(B) 14%
(C) 81%
(D) 86%

[Ans. D]