Assignment 8

AI24BTECH11008- Sarvajith

69. The following circuit where(where $R_L >>> R$) performs the operation of (2008)

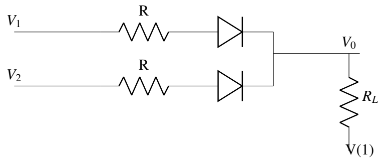


Fig. 0.1: 1

(A) OR gate for a negative logic system
(B) NAND gate for a negative logic system
(C) AND gate for a positive logic system
(D) AND gate for a negative logic system

70. In the T type master-slave J_K flip flop is shown along with the clock and input waveforms. The Q_n output of flip flop was zero initially. Identify the correct output waveform. (2008)

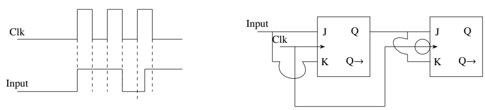
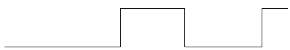
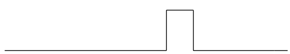


Fig. 0.2: 2





1 Common Data Questions

Common data for questions 71, 72 and 73: A beam of identical particles of mass m and energy E is incident from left on a potential barrier of width L (between $0 < x < L$) and height V_0 as shown in the figure ($E < V_0$) For x ¿ L there is

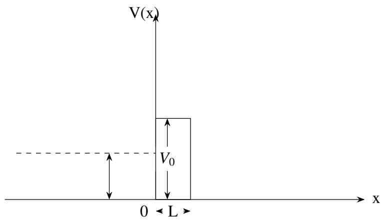


Fig. 0.3: 7

tunneling with a transmission coefficient $T > 0$. Let A_0, AB and AT denote the amplitudes for the incident, reflected and the transmitted waves, respectively.

71. Throughout $0 < x < L$, the wave-function (2008)
   (A) can be chosen to be real
   (B) is exponentially decaying
   (C) is generally complex
   (D) is zero

72. Let the probability current associated with the incident wave be S_0. Let R be the reflection coefficient. Then (2008)
   (A) the probability current vanishes in the classically forbidden region
   (B) the probability current is TS_0 for $x > L$
   (C) for, $x < 0$ the probability current is $S_0(1 + R)$
   (D) for $x > L$, the probability current is complex

73. The ratio of the reflected to the incident amplitude $\frac{A_B}{A_0}$ is (2008)
   (A) $1 - \frac{A_T}{A_0}$
   (B) $\sqrt{(1 - T)}$ in magnitude
   (C) a real negative number
   (D) $\sqrt{\left(1 - \left|\frac{A_T}{A_0}\right|^2\right)\frac{E}{V_0 - E}}$

Common Data for questions 74 and 75: Consider two concentric conducting spherical shells with inner and outer radii a, b and c, d as shown in the figure. Both the shells are given Q amount of positive charges.

74. The electric field in different regions are (2008)
   (A) $\bar{E} = 0$ for $r < a$; $\bar{E} = \frac{-Q}{4\pi\epsilon_0 r^2}\hat{r}$ for $a < r < b$;$\bar{E} = 0$ for $b < r < c$; $\bar{E} = \frac{Q}{4\pi\epsilon_0 r^2}\hat{r}$ for $r > d$
   (B) $\bar{E} = 0$ for $a < r < b$; $\bar{E} = \frac{-Q}{4\pi\epsilon_0 r^2}\hat{r}$ for $r < a$; $\bar{E} = \frac{-Q}{4\pi\epsilon_0 r^2}\hat{r}$ for $b < r < c$; $\bar{E} = \frac{Q}{4\pi\epsilon_0 r^2}\hat{r}$ for $r > d$
   (C) $\bar{E} = \frac{-Q}{4\pi\epsilon_0 r^2}\hat{r}$ for $r < a$; $\bar{E} = 0$ for $a < r < b$;$\bar{E} = 0$ for $b < r < c$; $\bar{E} = \frac{2Q}{4\pi\epsilon_0 r^2}\hat{r}$ for $r > d$

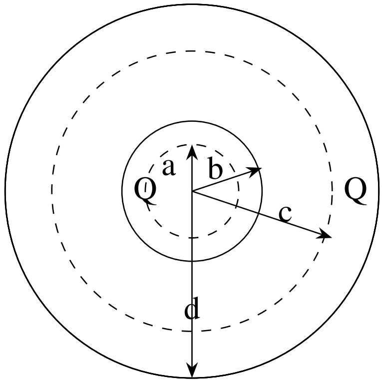


Fig. 0.4: 8

(D) $\bar{E} = 0$ for $r < a$; $\bar{E} = 0$ for $a < r < b$;$\bar{E} = fracQ4\pi\epsilon_0 r^2 \hat{r}$ for $b < r < c$; $\bar{E} = \frac{2Q}{4\pi\epsilon_0 r^2}\hat{r}$ for $r > d$

75. In order to have equal surface charge densities on the outer surfaces of both the shells, the following conditions should be satisfied (2008)

(A) d = 4b and c = 2a
(B) d = 2b and $\sqrt{2}$a
(C) d = $\sqrt{2}$b and $c > a$
(D) $d > b$ and c = $\sqrt{2}$a

2 Linked Answer Questions:

Q.76 to Q.85 carry 2 marks each. **Statement for linked answer questions 76 and 77** Consider the β-decay of a free neutron at rest in the laboratory.

76. Which of the following configurations of the decay products corresponds to the largest energy of the anti-neutrino $\bar{\nu}$? (rest mass of electron $m_e = 0.51\ \frac{MeV}{c^2}$, rest mass of proton $m_p = 938.27\ \frac{MeV}{c^2}$ and rest mass of neutron mn = 939.57 $\frac{MeV}{c^2}$) (2008)

(A) In the laboratory, proton is produced at rest
(B) In the laboratory, momenta of proton, electron and the anti-neutrino all have the same magnitude
(C) In the laboratory, proton and electron fly-off with (nearly) equal and opposite momenta
(D) In the laboratory, electron is produced at rest

77. Using the result of the above problem, answer the following. Which of the following represents approximately the maximum allowed energy of the anti-neutrino $\bar{\nu}$? (2008)

(A) 1.3 MeV
(B) 0.8 MeV
(C) 0.5 MeV
(D) 2 MeV

Statement for Linked Answer Questions 78 and 79 Consider a two dimensional electron gas of N electrons of mass m each in a system of size $L \times L$.

78. The density of states between energy $\epsilon$and$\epsilon + d\epsilon$ is (2008)
   (A) $\frac{4\pi L^2 m}{h^2} d\epsilon$
   (B) $\frac{4\pi L^2 m}{h^2} \frac{1}{\sqrt{\epsilon}} d\epsilon$
   (C) $\frac{4\pi L^2 m}{h^2} \sqrt{\epsilon} d\epsilon$
   (D) $\frac{4\pi L^2 m}{h^2} \epsilon d\epsilon$
79. The ground state energy E_0 of the system in terms of the Fermi energy E_F and the number of electrons N is given by (2008)
   (A) $\frac{1}{3} N E_F$
   (B) $\frac{1}{2} N E_F$
   (C) $\frac{2}{3} N E_F$
   (D) $\frac{3}{5} N E_F$

Statement for linked answer questions 80 and 81: The rate of a clock in a spaceship "Suryashakti" is observed from each to be $\frac{3}{5}$ of the rate of the clocks on earth.

80. The speed of the spaceship "Suryashakti" relative to earth is (2008)
   (A) $\frac{4}{5} c$
   (B) $\frac{3}{5} c$
   (C) $\frac{9}{10} c$
   (D) $\frac{2}{5} c$
81. The rate of a clock in a spaceship "Aakashganga" is observed from earth to be $\frac{5}{13}$ of the rate of the clocks on earth. If both Aakashganga and Suryashakti are moving in the same direction relative to someone on earth, then the speed of Aakashganga relative to Suryashakti is (2008)
   (A) $\frac{12}{13} c$
   (B) $\frac{4}{5} c$
   (C) $\frac{8}{17} c$
   (D) $\frac{5}{6} c$

Statement for Linked Answer Questions 82 and 83: The following circuit contains three operational amplifiers and resistors (2008)

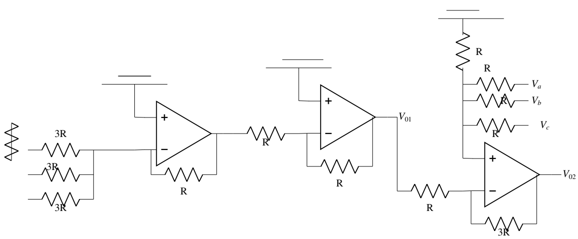


Fig. 0.5: 9

82. The output voltage at the end of second operational amplifier V_{01} is (2008)
   (A) $V_{01} = 3(V_a + V_b + V_c)$
   (B) $V_{01} = -\frac{1}{3}(V_a + V_b + V_c)$
   (C) $V_{01} = \frac{1}{3}(V_a + V_b + V_c)$

(D) $V_{01} = \frac{4}{3}(V_a + V_b + V_c)$

83. The output V_{02} (at the end of third op amp) of the above circuit is (2008)

(A) $V_{02} = 2(V_a + V_b + V_c)$
(B) $V_{02} = 3(V_a + V_b + V_c)$
(C) $V_{02} = -\frac{1}{2}(V_a + V_b + V_c)$
(D) Zero

Statement for Linked Answer Questions 84 and 85 The set V of all polynomials of a real variable x of degree two or less and with real coefficients, constitutes a real linear vector space $V = \{c_0 + c_1 x + c_2 x^2 : c_0, c_1, c_2 \in R\}$.

84. For $f(x) = a_0 + a_1 x + ax^2 \in V$ and $g(x) = b_0 + b_1 x + b_2 x^2 \in V$, which one of the follwoing constitutes an acceptable scalar product? (2008)

(A) $(f, g) = a_0^2 b_0 + a_1^2 b_1 + a_2^2 b_2$
(B) $(f, g) = a_0^2 b_0^2 + a_1^2 b_1^2 + a_2^2 b_2^2$
(C) $(f, g) = a_0 b_0 - a_1 b_1 + a_2 b_2$
(D) $(f, g) = a_0^2 b_0 + \frac{a_1 b_1}{2} + \frac{a_2 b_2}{3}$

85. Using the scalar product obtained in the above question, identify the subspace of V that is orthogonal to $(1 + x)$: (2008)

(A) $\{f(x) : b(1 - x) + cx^2; b, c \in R\}$
(B) $\{f(x) : b(1 - 2x) + cx^2; b, c \in R\}$
(C) $\{f(x) : b + cx^2; b, c \in R\}$
(D) $\{f(x) : bx + cx^2; b, c \in R\}$