# ELECTRONICS SOLUTIONS

## GATE-2010

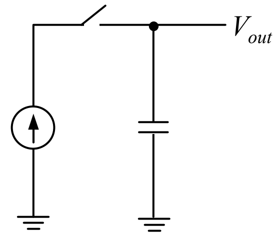
Q1. The voltage resolution of a 12-bit digital to analog converter (DAC), whose output varies from $-10\,V$ to $+10\,V$ is, approximately

(a) $1\,mV$ (b) $5\,mV$ (c) $20\,mV$ (d) $100\,mV$

Ans: (b)

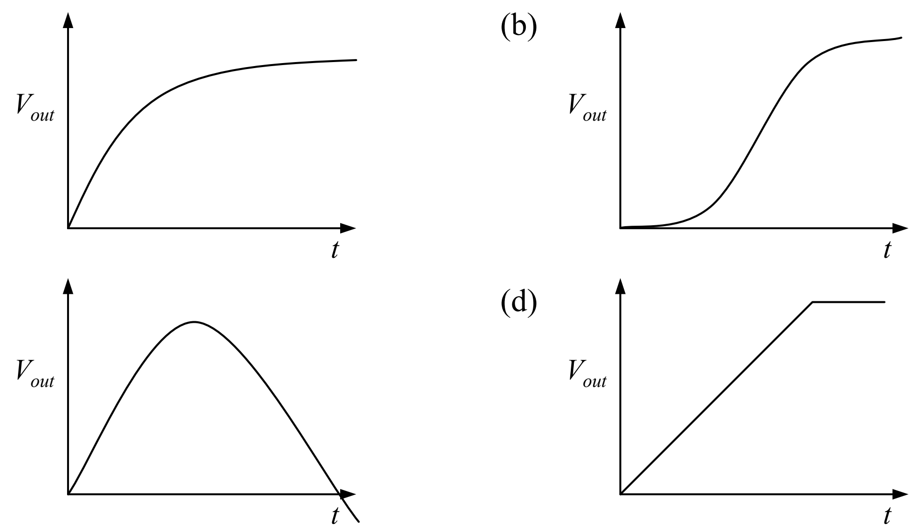
Solution: Voltage resolution$=\dfrac{20V}{2^{12}-1}=4.8\,mV$

Q2. The figure shows a constant current source charging a capacitor that is initially uncharged.




If the switch is closed at $t=0$, which of the following plots depicts correctly the output voltage of the circuit as a function of time?

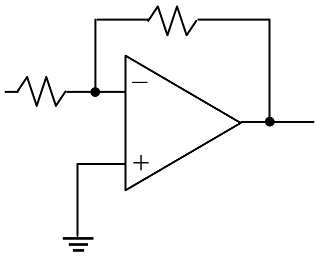
(a) (b) (c) (d)

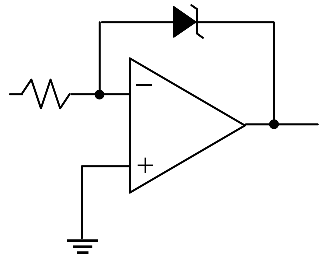


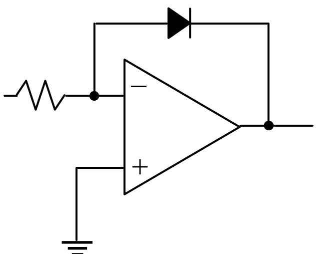

Ans: (d)

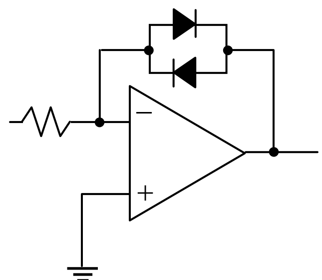
Solution: $I_0=\dfrac{CdV_0}{dt}\Rightarrow V_0=\dfrac{I_0}{C}t$

Q3. In one of the following circuits, negative feedback does not operate for a negative input. Which one is it? The opamps are running from ± 15 V supplies.

(a)


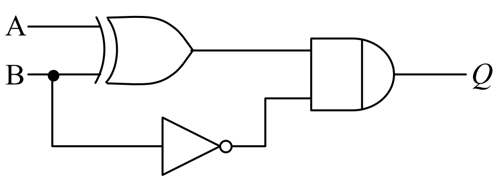
(b)


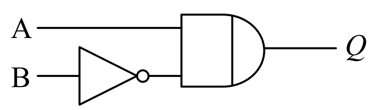
(c)


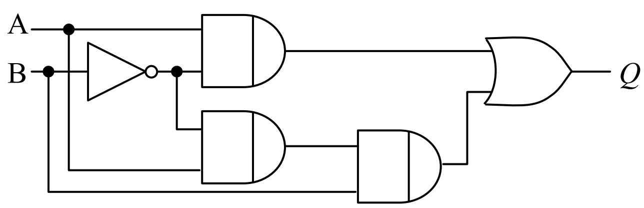
(d)


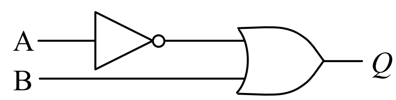
Ans: (c)

Q4. For any set of inputs, A and B, the following circuits give the same output, Q, except one. Which one is it?

(a)



(b)



(c)



(d)



Ans: (d)

**GATE-2011**

Q5. Which of the following statements is **CORRECT** for a common emitter amplifier circuit?

(a) The output is taken from the emitter

(b) There is $180^{o}$ phase shift between input and output voltages

(c) There is no phase shift between input and output voltages

(d) Both *p-n* junctions are forward biased

Ans: (b)

Q6. For an intrinsic semiconductor, $m_e^*$ and $m_h^*$ are respectively the effective masses of electrons and holes near the corresponding band edges. At a finite temperature the position of the Fermi level

(a) depends on $m_e^*$ but not on $m_h^*$

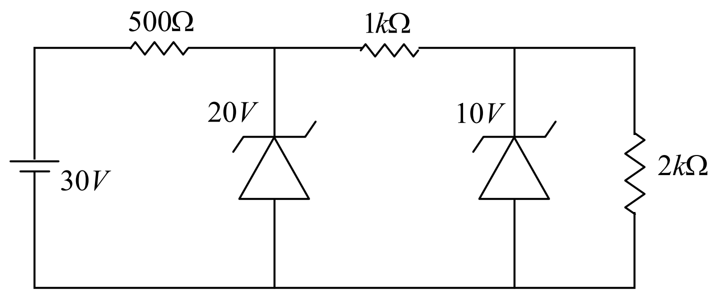
(b) depends on $m_h^*$ but not on $m_e^*$

(c) depends on both $m_e^*$ and $m_h^*$

(d) depends neither on $m_e^*$ nor on $m_h^*$

Ans: (c)

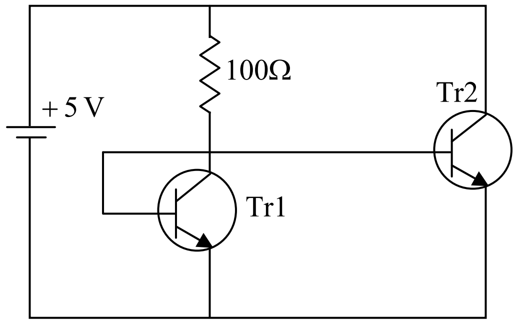
Q7. In the following circuit, the voltage across and the current through the 2 kΩ resistance are




(a) 20 V, 10 mA (b) 20 V, 5 mA (c) 10 V, 10 mA (d) 10 V, 5 mA

Ans: (d)

Q8. In the following circuit, Tr1 and Tr2 are identical transistors having $V_{BE}$ = 0.7 V. The current passing through the transistor Tr2 is




(a) 57 mA (b) 50 mA (c) 48 mA (d) 43 mA

Ans: (d)

Solution: Current through $100\,\Omega$, $I = \dfrac{5-0.7}{100} = 43\,mA$

$I = I_C + 2I_B \approx I_C = 43\,mA$.

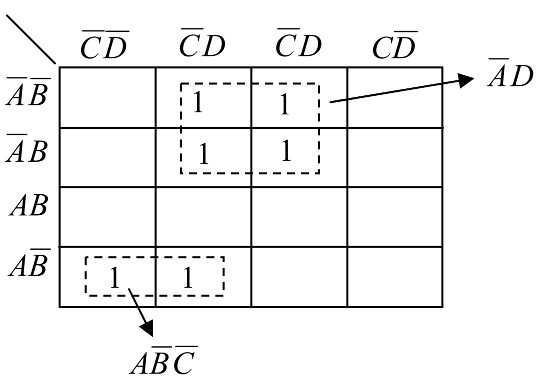
Q9. The following Boolean expression

$Y = A\cdot\overline{B}\cdot\overline{C}\cdot\overline{D} + \overline{A}\cdot B\cdot\overline{C}\cdot D + \overline{A}\cdot\overline{B}\cdot\overline{C}\cdot D + \overline{A}\cdot\overline{B}\cdot C\cdot D + \overline{A}\cdot B\cdot C\cdot D + A\cdot\overline{B}\cdot\overline{C}\cdot D$ can be simplified to

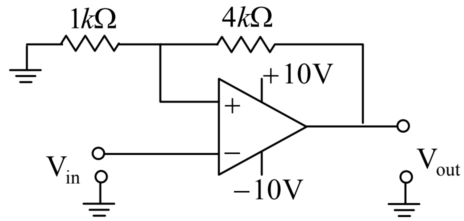
(a) $\overline{A}\bullet\overline{B}\bullet C + A\bullet\overline{D}$ (b) $\overline{A}\bullet B\bullet\overline{C} + A\bullet\overline{D}$

(c) $A\bullet\overline{B}\bullet\overline{C} + \overline{A}\bullet D$ (d) $A\bullet\overline{B}\bullet C + \overline{A}\bullet D$

Ans: (c)

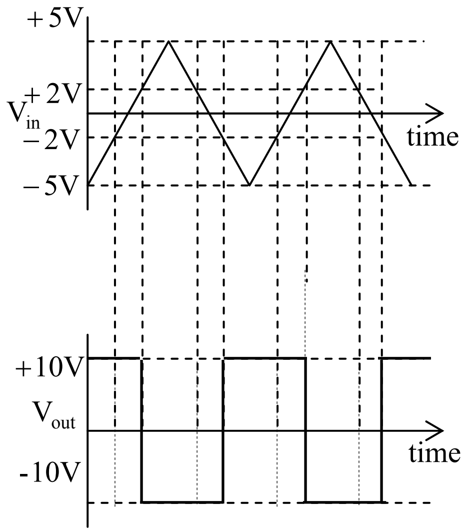


Q10. Consider the following circuit

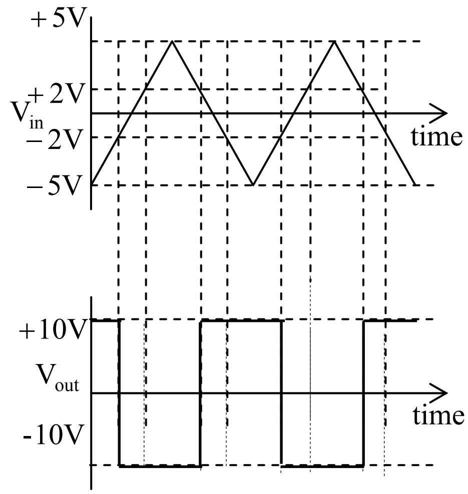



Which of the following correctly represents the output $V_{out}$ corresponding to the input $V_{in}$?

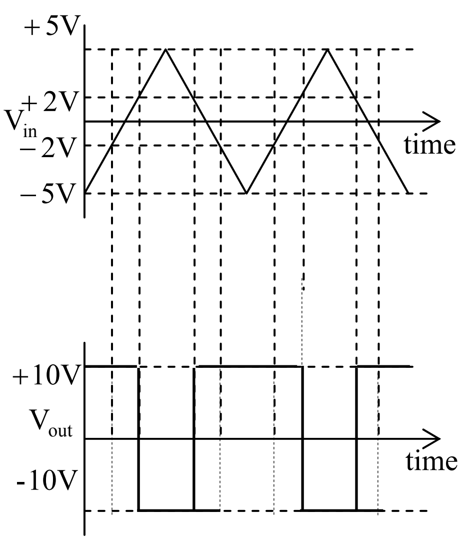
(a)



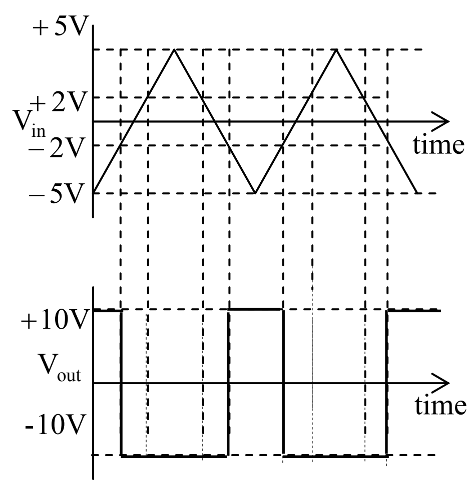

(b)




(c)




(d)




Ans: (a)

Solution: $V_{ut} = \left(\frac{1}{1+4}\right)\times 10 = +2V, \quad V_{lt} = \left(\frac{1}{1+4}\right)\times -10 = -2V.$

**GATE-2012**

Q11. If the peak output voltage of a full wave rectifier is 10 V, its d.c. voltage is

(a) 10.0 V (b) 7.07 V (c) 6.36 V (d) 3.18 V

Ans: (c)

Solution: $V_{dc} = \frac{2V_m}{\pi} = \frac{2\times 10}{22/7} = \frac{14\times 10}{22} = \frac{70}{11} = 6.36V$

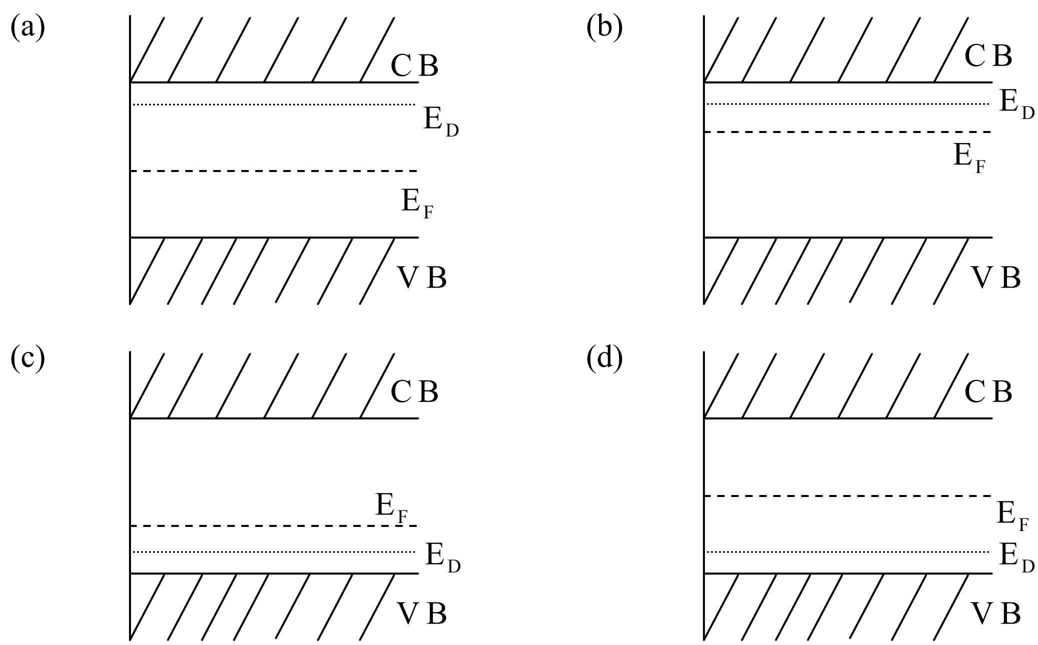
Q12. A *Ge* semiconductor is doped with acceptor impurity concentration of $10^{15}$ atoms/cm$^3$. For the given hole mobility of 1800 cm$^2$/V-s, the resistivity of the material is

(a) 0.288 Ω cm (b) 0.694 Ω cm (c) 3.472 Ω cm (d) 6.944 Ω cm

Ans: (c)

Solution: $\rho = \frac{1}{\sigma} = \frac{1}{N_A e u_h} = \frac{1}{10^{15}\times 1.6\times 10^{-19}\times 1800} = 3.47\Omega cm$

Q13. Identify the CORRECT energy band diagram for silcon doped with Arsenic. Here CB, VB, $E_D$ and $E_F$ are conduction band, valence band, impurity level and Fermi level, respectively.

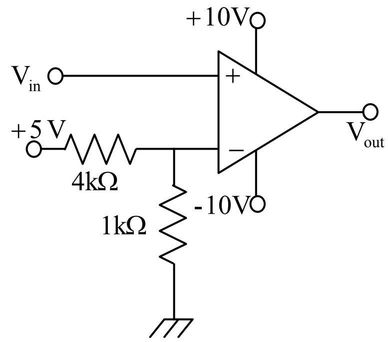



Ans: (b)

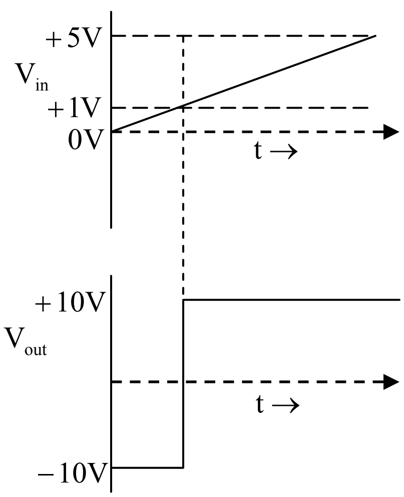
Solution: N-type material ( *Si* doped with $A_S$ ).

Q14. Consider the following OP-AMP circuit

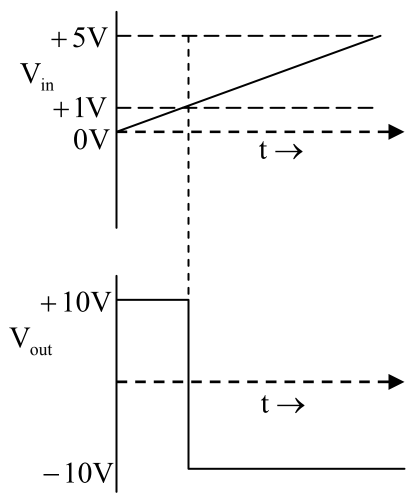
Which one of the following correctly represents the output $V_{out}$ corresponding to the input $V_{in}$?



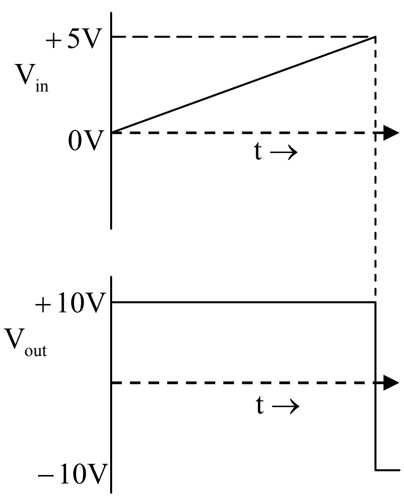

(a)



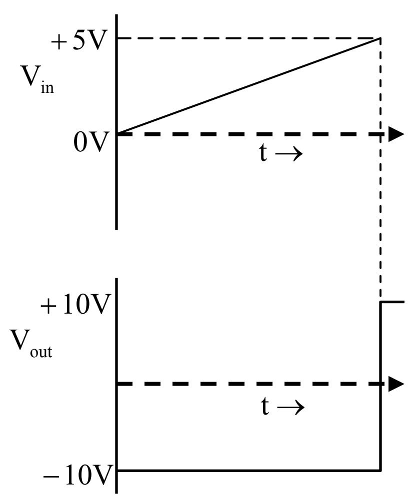

(b)




(c)




(d)




Ans: (a)

Solution: Voltage at inverting input $V_2 = \left(\frac{1}{1+4}\right)\times 5 = +1V$.

When $v_{in} > +1V$, $v_0 = +V_{CC}$ and when $v_{in} < +1V$, $v_0 = -V_{CC}$

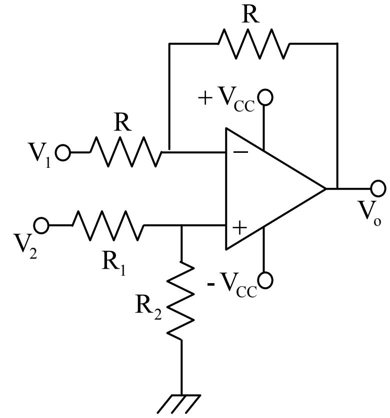
Q15. In the following circuit, for the output voltage to be $V_0 = \left(-V_1 + V_2/2\right)$ the ratio $R_1/R_2$ is

(a) 1/2

(b) 1

(c) 2

(d) 3




Ans: (d)

Solution: When $V_2 = 0, \quad v_{01} = -V_1$

when $V_1 = 0, \quad v_{02} = \left(1 + \frac{R}{R}\right)\left(\frac{R_2}{R_1 + R_2}\right)V_2$

Since $V_0 = -V_1 + \frac{V_2}{2} \Rightarrow 2 \cdot \frac{R_2}{R_1 + R_2} = \frac{1}{2} \Rightarrow \frac{R_1}{R_2} = 3$

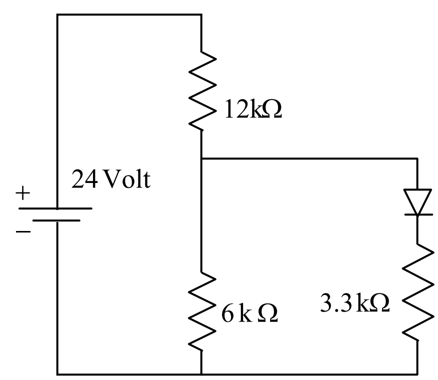
Q16. In the following circuit, the voltage drop across the ideal diode in forward bias condition is 0.7V. The current passing through the diode is

(a) 0.5 mA

(b) 1.0 mA

(c) 1.5 mA

(d) 2.0 mA




Ans: (b)

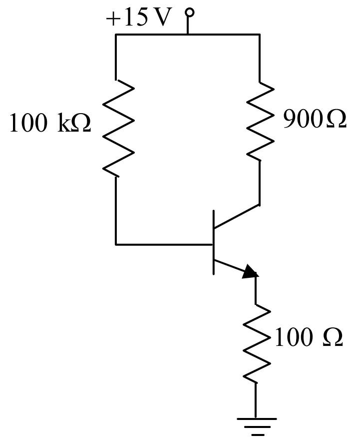
Solution: Let current through $12k\Omega$ is $I$ and through diode is $I_D$

Then $\quad 0.7 + I_D \times 3.3 = (I - I_D) \times 6$ (1)

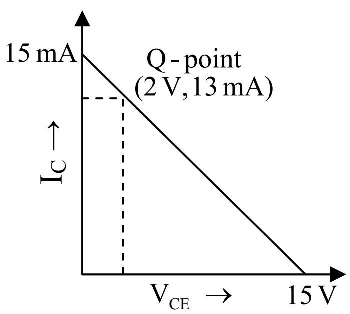
and $-24 + I \times 12 + (I - I_D) \times 6 = 0$ (2)

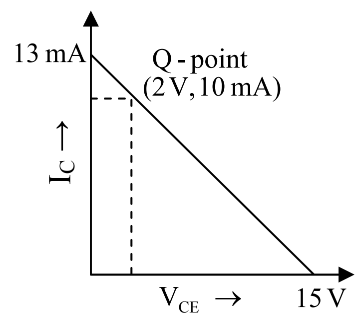
From (1) and (2) $I_D \approx 1mA$.

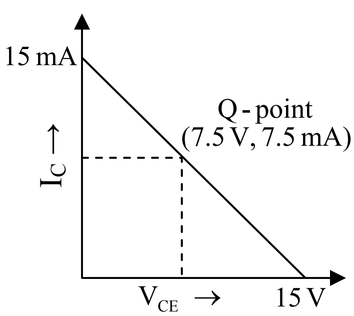
Q17. Consider the following circuit in which the current gain $\beta_{dc}$ of the transistor is 100.

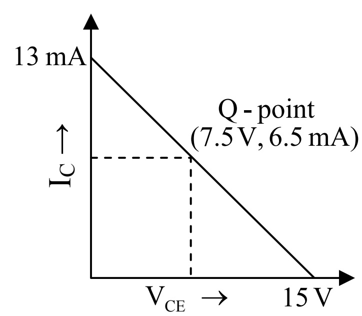



Which one of the following correctly represents the load line (collector current $I_C$ with respect to collector-emitter voltage $V_{CE}$) and Q-point of this circuit?

(a)



(b)



(c)



(d)



Ans: (a)

Solution: $I_B = \dfrac{V_{CC} - V_{BE}}{R_B + R_E} = \dfrac{15 - 0.7}{100\times10^3 + 100} \approx \dfrac{14.3}{100} mA.$

$$I_C \approx \beta I_B \approx 14.3mA \approx 13mA, V_{CE} = V_{CC} - I_C\left(R_C + R_E\right) = 15 - \left(900 + 100\right)\times 13\times10^{-3} = 2V.$$

$$I_{C,Sat} = \frac{V_{CC}}{R_C + R_E} = \frac{15}{1000} = 15\,mA.$$

**GATE-2013**

Q18. What should be the clock frequency of a $6-bit\ A/D$ converter so that its maximum conserved time is $32\mu s$ ?

(a) 1 $MHz$ (b) 2 $MHz$ (c) 0.5 $MHz$ (d) 4 $MHz$

Ans: (c)

Q19. A phosphorous doped silicon semiconductor (doping density: $10^{17}/cm^3$) is heated from 100°C to 200°C. Which one of the following statements is CORRECT?

(a) Position of Fermi level moves towards conduction band

(b) Position of dopant level moves towards conduction band

(c) Position of Fermi level moves towards middle of energy gap

(d) Position of dopant level moves towards middle of energy gap

Ans: (c)

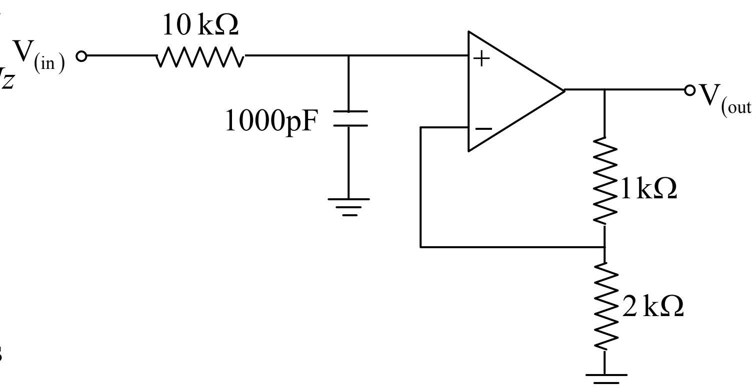
**Statement for Linked Answer Questions 20 and 21:**

Consider the following circuit

Q20. For this circuit the frequency above which the gain will decrease by 20 $dB$ per decade is

(a) 15.9 $kHz$ (b) 1.2 $kHz$

(c) 5.6 $kHz$ (d) 22.5 $kHz$




Ans: (a)

Solution: $f_H = \frac{1}{2\pi RC} = 16 kHz$

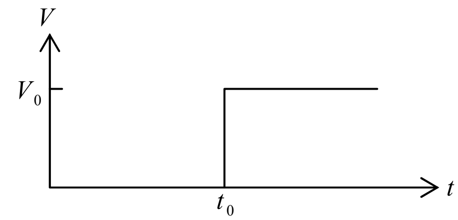
Q21. At 1.2 $kHz$ the closed loop gain is

(a) 1 (b) 1.5 (c) 3 (d) 0.5

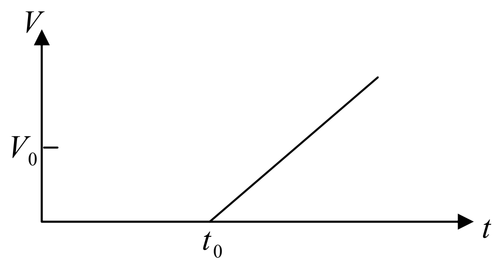
Ans: (b) $\left|\frac{v_0}{v_{in}}\right| = \frac{\left(1+R_F/R_1\right)}{\sqrt{1+\left(f/f_H\right)^2}} = 1.5$

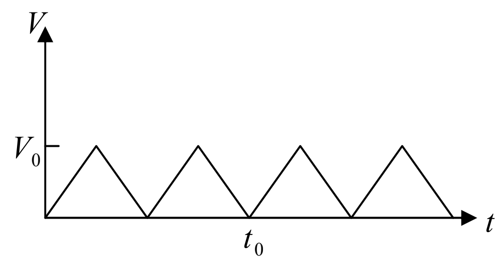
## GATE-2014

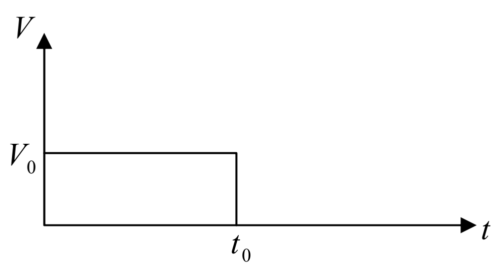
Q22. The input given to an ideal OP-AMP integrator circuit is

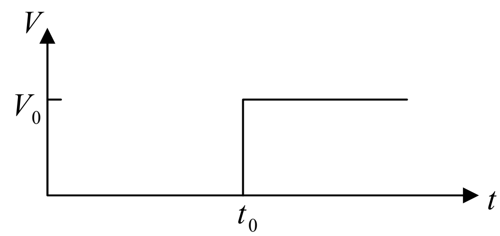



The correct output of the integrator circuit is

(a)



(b)



(c)



(d)



Ans: (a)

Q23. The minimum number of flip-flops required to construct a mod-75 counter is __________

Ans: 7

Q24. The donor concentration in a sample of $n$-type silicon is increased by a factor of 100. The shift in the position of the Fermi level at 300K, assuming the sample to non degenerate is ________ $meV$

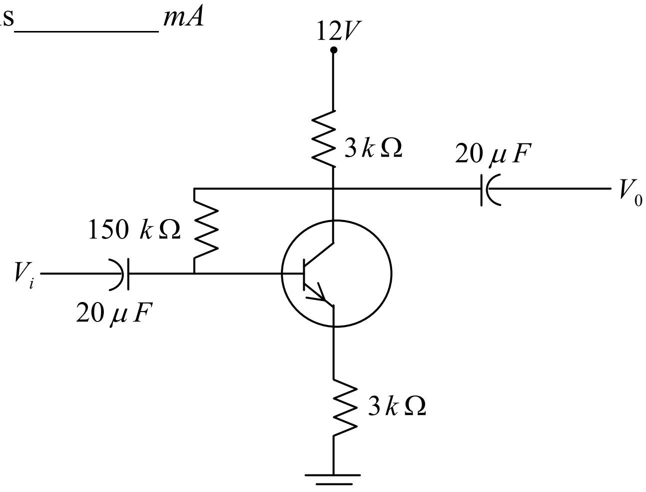
$(k_B T = 25 meV\ at\ 300K)$

Ans: 115.15

Solution: $E_C - E_F = kT\ln\left(\frac{N_c}{N_d}\right)$ and $E_C - E_F' = kT\ln\left(\frac{N_c}{100N_d}\right) = kT\ln\left(\frac{N_c}{N_d}\right) - kT\ln(100)$

Thus shift is $\Delta E = kT\ln(100) = 25\ln(100)\,meV = 115.15\,meV$

Q25. The current gain of the transistor in the following circuit is $\beta_{dc} = 100$. The value of collector current $I_C$ is_________ $mA$




Ans: 1.6

Solution: $I_B = \frac{V_{CC} - V_{BE}}{R_B + \beta(R_C + R_E)} = \frac{12-0}{150+100(3+3)} = 0.016\, mA \Rightarrow I_C = \beta I_B = 1.6\, mA$

Q26. In order to measure a maximum of $1V$ with a resolution of $1mV$ using a $n-$bit $\frac{A}{D}$ converter working under the principle of ladder network the minimum value of $n$ is ___________

Ans: 10

Solution: $1\times 10^{-3} = \frac{1}{2^n - 1} \Rightarrow n \approx 10$

Q27. A low pass fliter is formed by a resistance $R$ and a capacitance $C$. At the cut-off angular frequency $\omega_C = \frac{1}{RC}$ the voltage gain and the phase of the output voltage relative to the input voltage respectively are

(a) $0.71$ and $45^{\circ}$ (b) $0.71$ and $-45^{\circ}$ (c) $0.5$ and $-90^{\circ}$ (d) $0.5$ and $90^{\circ}$

Ans: (b)

Solution: $\frac{v_0}{v_{in}} = \frac{X_C}{R+X_C} = \frac{1}{\frac{R}{X_C}+1} = \frac{1}{1+j\omega CR}$

At $\omega = \omega_C = \frac{1}{RC} \Rightarrow \frac{v_0}{v_{in}} == \frac{1}{1+j} = \frac{1}{\sqrt{2}e^{j45^0}} = \frac{1}{\sqrt{2}}e^{-j45^0}$

**GATE-2015**

Q28. The band gap of an intrinsic semiconductor is $E_g = 0.72\,eV$ and $m_n^* = 6m_g^*$. At $300\,K$, the Fermi level with respect to the edge of the valence band (in $eV$) is at _______(upto three decimal places) $k_B = 1.38\times 10^{-23}\,JK^{-1}$

Ans.: 0.395

Solution: $E_i = \dfrac{E_c + E_v}{2} + \dfrac{3}{4}kT\ln\left(\dfrac{m_h^*}{m_n^*}\right)$

$$n_i = N_V e^{-(E_i - E_v)/kT} = \sqrt{N_c N_v}\,e^{-E_g/2kT}$$

$$\Rightarrow e^{-(E_i - E_v)/kT} = \sqrt{\frac{N_c}{N_v}}e^{-E_g/2kT} \Rightarrow e^{(E_i - E_v)/kT} = \sqrt{\frac{N_v}{N_c}}e^{E_g/2kT}$$

$$\frac{E_i - E_v}{kT} = \ln\left(\sqrt{\frac{N_v}{N_c}}\right) + \frac{E_g}{2kT} = \ln\left(\frac{m_h^*}{m_e^*}\right)^{\frac{3}{4}} + \frac{E_g}{2kT} \Rightarrow E_i - E_v = \frac{3}{4}kT\ln(6) + \frac{E_g}{2}$$

$$\Rightarrow E_i - E_v = \frac{3}{4}\times 0.026\times 1.7917 + \frac{0.72}{2} = 0.3949\,eV \approx 0.395\,eV$$

Q29. Which one of the following DOES NOT represent an exclusive OR operation for inputs $A$ and $B$?

(a) $(A+B)\overline{AB}$

(b) $A\overline{B} + B\overline{A}$

(c) $(A+B)(\overline{A}+\overline{B})$

(d) $(A+B)AB$

Ans.: (d)

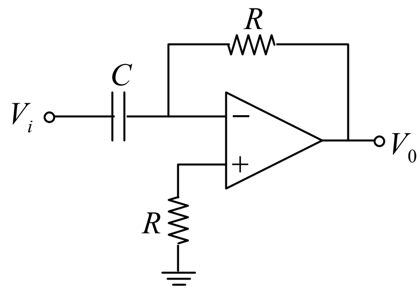
Solution: (a) $(A+B)\overline{AB} = (A+B)(\overline{A}+\overline{B}) = A\overline{B} + \overline{A}B$

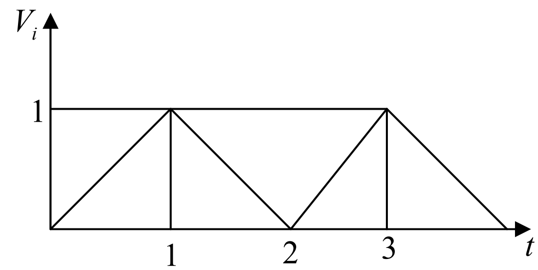
(b) $A\overline{B} + \overline{A}B$

(c) $A\overline{B} + \overline{A}B$

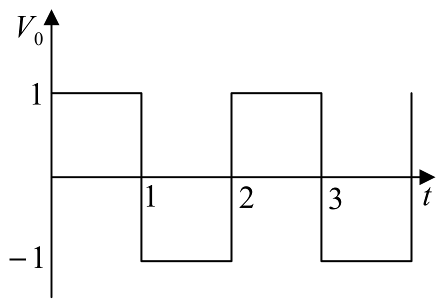
(d) $(A+B)AB = AB$

Q30. Consider the circuit shown in the figure, where $RC = 1$. For an input signal $V_i$ shown below, choose the correct $V_0$ from the options:

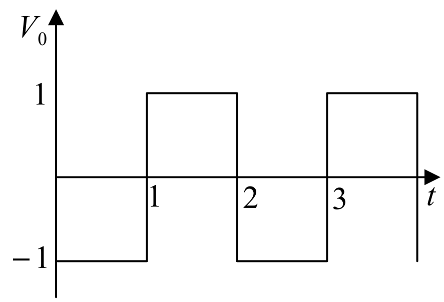


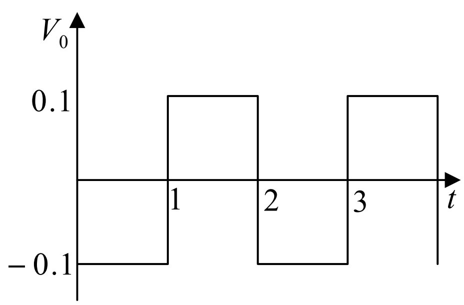

(a)



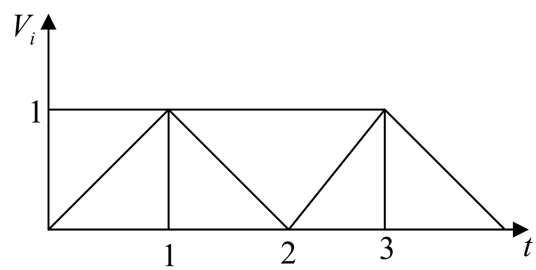

(b)




(c)




(d)

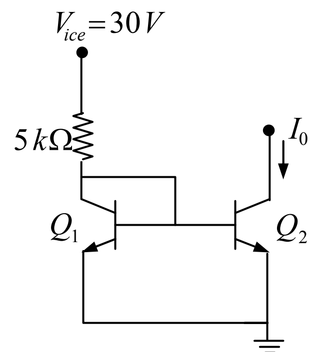



Ans.: (b)

Solution: $C\dfrac{dv_i}{dt} = \dfrac{0 - v_0}{R} \Rightarrow v_0 = -RC\dfrac{dv_{in}}{dt} = -\dfrac{dv_{in}}{dt}$

$v_{in} = +t \;\Rightarrow v_0 = -1V$ and $v_{in} = -t \;\Rightarrow v_0 = +1V$

Q31. In the simple current source shown in the figure, $Q_1$ and $Q_2$ are identical transistors with current gain $\beta = 100$ and $V_{BE} = 0.7V$



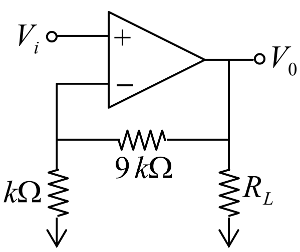

The current $I_0(\text{in } mA)$ is __________ (upto two decimal places)

Ans.: 5.86

Solution: $-V_{CC} + I_C R_C + V_{BE} = 0$

$$I_C = \frac{30-0.7}{5} = \frac{29.3}{5} = 5.86\ mA$$

Q32. In the given circuit, if the open loop gain $A = 10^5$ the feedback configurations and the closed loop gain $A_f$ are



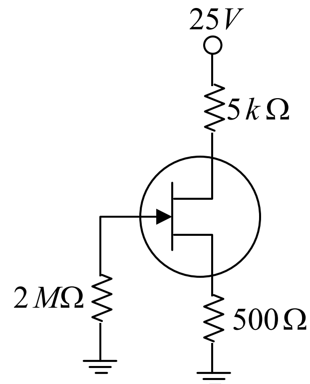

(a) series-shunt, $A_f = 9$ (b) series-series, $A_f = 10$

(c) series-shunt, $A_f = 10$ (d) shunt-shunt, $A_f = 10$

Ans.: (c)

Solution: $A_F = \left(1 + \frac{R_F}{R_1}\right) = (1+9) = 10.$

Q33. In the given circuit, the voltage across the source resistor is $1\ V$. The drain voltage (in $V$) is ___________




Ans.: 15

Solution: $V_S = I_D R_S \Rightarrow I_D = \frac{1}{500} A \Rightarrow V_D = V_{DD} - I_D R_D = 25 - \frac{1}{500} \times 5000 \Rightarrow V_D = 15V$

**GATE-2016**

Q34. The number density of electrons in the conduction band of a semiconductor at a given temperature is $2\times10^{19}\ m^{-3}$. Upon lightly doping this semiconductor with donor impurities, the number density of conduction electrons at the same temperature becomes $4\times10^{20}\ m^{-3}$. The ratio of majority to minority charge carrier concentration is ________.

Ans : 400

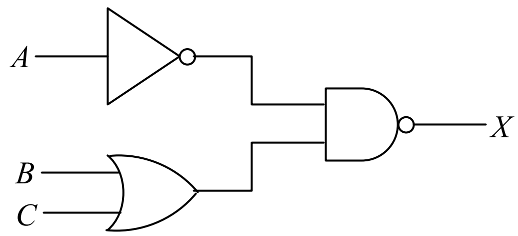
Solution: Intrinsic carrier concentration is $n_i = 2\times10^{19}\ m^{-3}$

Majority carrier concentration is $n = 4\times10^{20}\ m^{-3}$

Minority carrier concentration is $p = \frac{n_i^2}{n} = \frac{\left(2\times10^{19}\right)^2}{4\times10^{20}} = 10^{18}\ m^{-3}$

The ratio of majority to minority charge carrier concentration is $\frac{n}{p} = \frac{4\times10^{20}}{10^{18}} = 400$

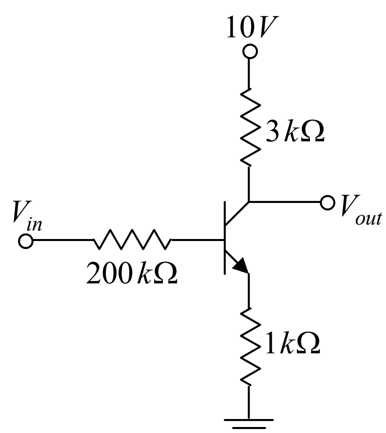
Q35. For the digital circuit given below, the output $X$ is




(a) $\overline{\overline{A}+B.C}$ (b) $\overline{\overline{A}\,.(B+C)}$ (c) $\overline{A.}\,(B+C)$ (d) $A+\overline{(B.C)}$

Ans.: (b)

Q36. For the transistor shown in the figure, assume $V_{BE}=0.7V$ and $\beta_{dc}=100$. If $V_{in}=5V, V_{out}$ (in Volts) is _________. (Give your answer upto one decimal place)




Ans.: 5.7

Solution: $I_B=\dfrac{V_{in}-V_{BE}}{R_B+\beta R_E}=\dfrac{5-0.7}{200+100}=\dfrac{4.3}{300}mA\ I_C=\beta I_B=1.433\ mA$

$$V_{out}=V_{CC}-I_CR_C \Rightarrow V_{out}=10-1.433\times 3=5.7\ V$$

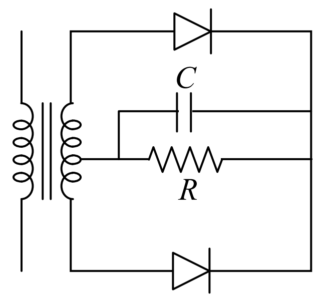
**GATE-2017**

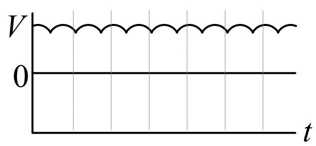
Q37. The best resolution that a 7 bit A/D convertor with $5V$ full scale can achieve is.............. $mV$. (up to two decimal places)

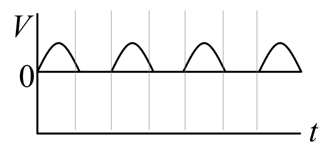
Ans. : 39.37

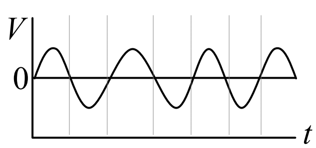
Solution: Resolution $= \dfrac{5}{2^7 - 1} = 39.37\ mV$

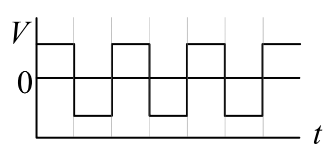
Q38. In the figure given below, the input to the primary of the transformer is a voltage varying sinusoidally with time. The resistor $R$ is connected to the centre tap of the secondary. Which one of the following plots represents the voltage across the resistor $R$ as a function of time?




(a)



(b)



(c)



(d)



Ans. : (a)

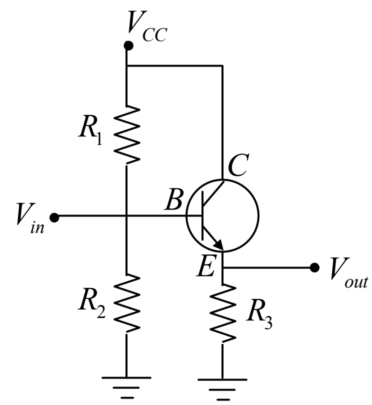
Solution: Full wave rectifier with RC filter.

Q39. The minimum number of NAND gates required to construct an OR gate is:

(a) 2 (b) 4 (c) 5 (d) 3

Ans. : (d)

Q40. For the transistor amplifier circuit shown below with $R_1 = 10\,k\Omega, R_2 = 10\,k\Omega, R_3 = 1\,k\Omega$, and $\beta - 99$. Neglecting the emitter diode resistance, the input impedance of the amplifier looking into the base for small ac signal is………….$k\Omega$. (up to two decimal places)

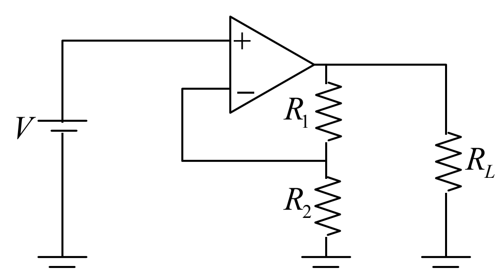



Ans. : 4.75

Solution: $Z_i = Z_b \,||\, R'$ where $Z_b \approx \beta R_3 = 99k\Omega$ and $R' = R_1 \,||\, R_2 = 5k\Omega$

$\Rightarrow Z_i = Z_b \,||\, R' = 4.75k\Omega$

Q41. Consider an ideal operational amplifier as shown in the figure below with $R_1 = 5\,k\Omega, R_2 = 1\,k\Omega, R_L = 100\,k\Omega$. For an applied input voltage $V = 10\,mV$, the current passing through $R_2$ is…………….. $\mu A$. (up to two decimal places)




Ans. : 10.0

Solution: $I_2 = \frac{V}{R_2} = \frac{10}{1} = 10\,\mu A$