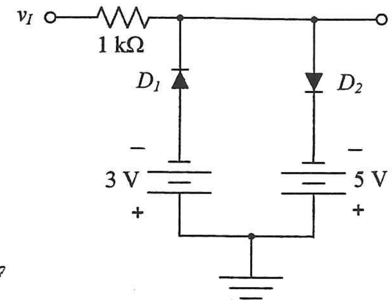
ECE 3200
Test 2
Solutions

A) The circuit shown below is intended to be a parallel-based clipper, but it has been designed incorrectly. Which of the following changes would correct the design?

a: Reversing the polarity of the 5 V battery
b: Reversing the polarity of D_2
c: Both a and b
d: Reversing the polarity of the 3 V battery
e: None of the above



(See text sec. 2.3.1)
The 5V battery should be reversed to create a positive clipping threshold.

B) Which of the following actions is performed by a clamper circuit?

a: Eliminating portions of a signal above or below a specified level
b: Increasing the peak-to-peak amplitude of a signal
c: Removing low frequency components from a signal
d: Maintaining the frequency of a periodic signal at a constant value
e: None of the above

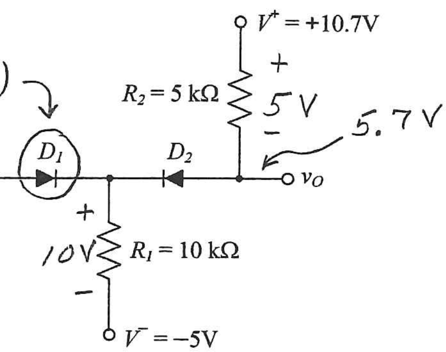
(See text sec. 2.3.2)
A clamper shifts the dc level of a signal without modifying the shape of the waveform.

C) The parameters of the diodes in the circuit below are $V_\gamma = 0.7$ V and $r_f = 0$. Which of the following is closest to the value of the output voltage v_O when $v_I = 0$ V?

a: 0 V
b: 3 V
c: 6 V
d: 9 V
e: 12 V

When $v_I < 5.7$ V,
D_1 is off (open circuit)
and D_2 is on.

From KVL, voltage divider,
$v_O = +10.7\text{V} - 5\text{V} = 5.7\text{V}$



D) How many pn junctions are contained in a bipolar junction transistor?

a: 0
b: 1
c: 2
d: 3
e: None of the above

(See text sec. 5.1)
1) BE junction
2) BC junction

E) The common-emitter current gain of a bipolar junction transistor is equal to 90. If the transistor is operating in the forward-active mode, and the emitter current is 5.46 mA, which of the following is closest to the value of the collector current?

a: 5.5 mA
b: 5.4 mA
c: 5.3 mA
d: 5.2 mA
e: 5.1 mA

$$I_C = \alpha I_E = \left(\frac{\beta}{1+\beta}\right) I_E$$

$$= \left(\frac{90}{1+90}\right)(5.46\,mA) = 5.4\,mA$$

F) The common-emitter current gain of a bipolar junction transistor is equal to 100. If the base current is 100 μA and the emitter current is 1 mA, which of the following is closest to the value of the collector current?

a: 0.9 mA
b: 1.0 mA
c: 1.1 mA
d: 10.0 mA
e: 10.1 mA

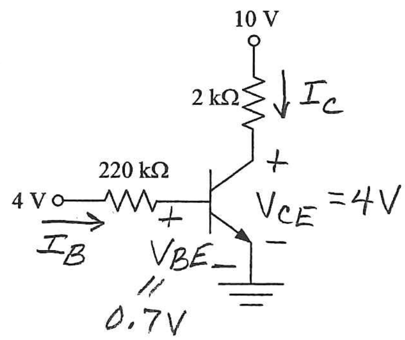
$$I_E = I_B + I_C \Rightarrow I_C = I_E - I_B$$

$$\Rightarrow I_C = 1\,mA - 0.1\,mA = 0.9\,mA$$

(Note : $I_C \neq \beta I_B \Rightarrow$ Not in F.A. Mode)

G) In the circuit shown below, $V_{CE} = 4$ V. Which of the following is closest to the value of β?

a: 50
b: 100
c: 150
d: 200
e: 250



$V_{CE} > 0.2V \Rightarrow$ F.A. Mode

$$I_C = \frac{10V - 4V}{2K\Omega} = 3\,mA$$

$$I_B = \frac{4V - 0.7V}{220K\Omega} = 0.015\,mA$$

$$\beta = \frac{I_C}{I_B} = \frac{3\,mA}{0.015\,mA} = 200$$

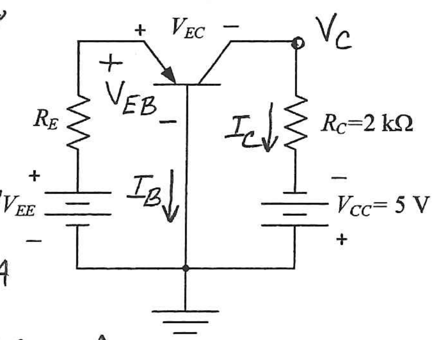
H) For the transistor in the circuit shown below, $\beta = 65$. Current is flowing in the circuit, and $V_{EC} = 1.5$ V. Which of the following is closest to the value of the base current?

a: 0.01 mA
b: 0.02 mA
c: 0.03 mA
d: 0.04 mA
e: 0.05 mA

Current is flowing and $V_{EC} > 0.2\,V$

$\Rightarrow$ F.A. Mode

$\Rightarrow V_{EB} = 0.7\,V$

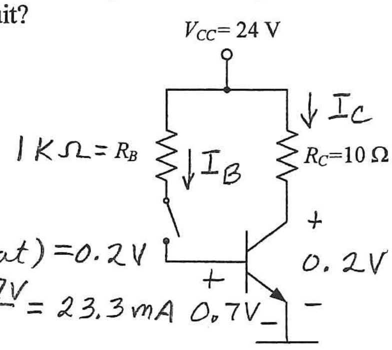


$$V_C = V_{EB} - V_{EC} = 0.7V - 1.5V = -0.8V$$

$$\Rightarrow I_C = \frac{-0.8V - (-5V)}{2\,K\Omega} = 2.1\,mA$$

$$\Rightarrow I_B = \frac{I_C}{\beta} = \frac{2.1\,mA}{65} \cong 0.032\,mA$$

I) The transistor in the circuit below is intended to function as a switch. Three transistors are available: Q_1, for which $\beta = 90$, Q_2, for which $\beta = 120$, and Q_3, for which $\beta = 150$. If $R_B = 1$ kΩ, which of the transistors would be acceptable for use in the circuit?



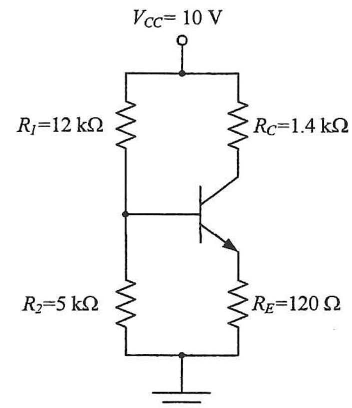
a: All three are acceptable.
b: Q_1 and Q_2 are acceptable, but Q_3 is not.
c: Q_2 and Q_3 are acceptable, but Q_1 is not.
d: Q_3 is acceptable, but Q_1 and Q_2 are not.
e: No transistor is acceptable.

Transistor must be in saturation when switch is closed $\Rightarrow V_{CE} = V_{CE(sat)} = 0.2V$

$I_C = \dfrac{24V - 0.2V}{10\Omega} = 2.38A$, $I_B = \dfrac{24V - 0.7V}{1K\Omega} = 23.3mA$ 0.7V

$I_C < \beta I_B \Rightarrow \beta > \dfrac{I_C}{I_B} = \dfrac{2.38A}{0.0233A} \cong 102$ Note $\beta > 102$ for Q_2 & Q_3

J) Which of the following values of β will cause the circuit below to be bias stable?



a: 100
b: 200
c: 300
d: Both a and b
e: None of the above

Bias stable if

$R_{TH} < 0.1(1+\beta)R_E$

$\Rightarrow \beta > \dfrac{R_{TH}}{0.1 R_E} - 1$

$\Rightarrow \beta > \dfrac{(12K\Omega \| 5K\Omega)}{(0.1)(0.12K\Omega)} - 1 \cong 293$

K) Which of the following are examples of bipolar transistor biasing methods?

a: Single base resistor biasing and voltage divider biasing
b: Forward biasing and reverse biasing
c: Forward-active mode biasing and saturation mode biasing
d: Thevenin equivalent biasing and Norton equivalent biasing
e: None of the above

See text sec. 5.4

L) A pnp BJT with $g_m = 32.2$ mA/V and $r_\pi = 6.2$ kΩ is biased in the forward-active mode. The transistor's temperature is 300 K. Which of the following is closest to the value of β?

a: 120
b: 140
c: 160
d: 180
e: 200

$g_m = \dfrac{I_{CQ}}{V_T}$ and $r_\pi = \dfrac{V_T}{I_{BQ}}$

$\Rightarrow g_m r_\pi = \left(\dfrac{I_{CQ}}{\cancel{V_T}}\right)\left(\dfrac{\cancel{V_T}}{I_{BQ}}\right) = \dfrac{I_{CQ}}{I_{BQ}} = \beta$

$\Rightarrow \beta = (32.2 \frac{mA}{\cancel{V}})(6.2 \cancel{K\Omega}) \cong 199.6$

M) Which of the following amplifiers should have low input resistance and high output resistance?

a: Voltage amplifiers
b: Transconductance amplifiers
c: Current amplifiers
d: Transresistance amplifiers
e: None of the above

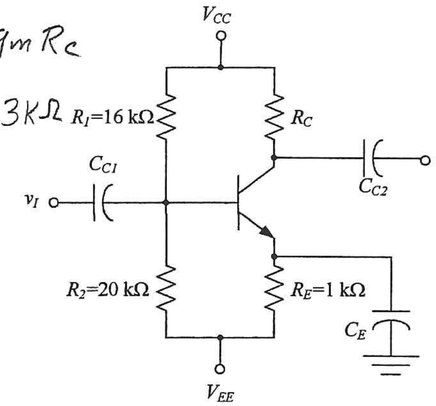
See text sec. 6.3

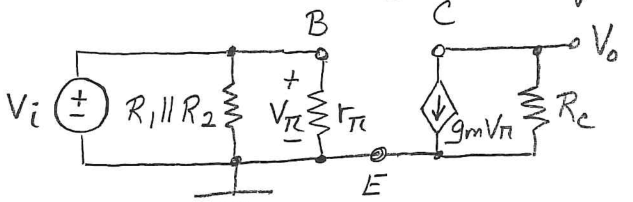
N) For the transistor in the circuit below, $g_m = 30$ mA/V, $V_A = \infty$, and $r_\pi = 1.5$ kΩ. The capacitors have negligible impedance at signal frequencies. Which of the following is closest to the value of R_C that will cause the circuit to have a small-signal, ac voltage gain of −90?

a: 90 kΩ
b: 60 kΩ
c: 30 kΩ
d: 3 kΩ
e: 1 kΩ

$$A_v = \frac{V_o}{V_i} = \frac{-g_m V_\pi R_C}{V_\pi} = -g_m R_C$$

$$\Rightarrow R_C = \frac{A_v}{-g_m} = \frac{-90}{-30\ \frac{mA}{V}} = 3\,k\Omega$$





O) The transistor in the circuit below is operating in the forward-active mode. Which of the following will happen if the value of R_C is increased?

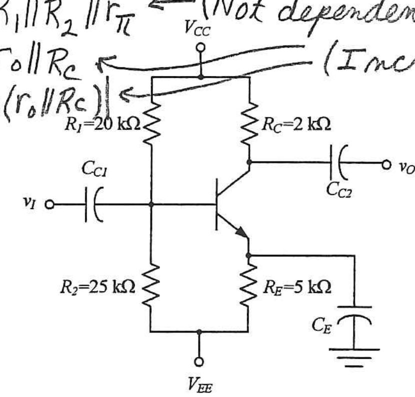
a: Both R_i and $|A_v|$ will increase.
b: R_i will decrease and $|A_v|$ will increase.
c: Both R_o and $|A_v|$ will increase.
d: R_o will increase and $|A_v|$ will remain constant.
e: None of the above

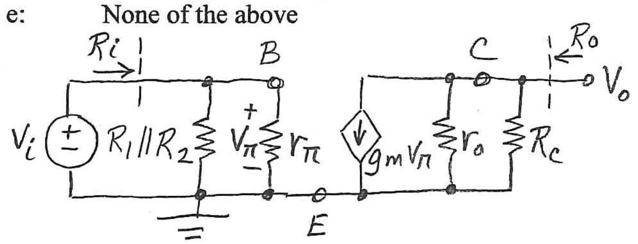
$R_i = R_1 \| R_2 \| r_\pi$ ← (Not dependent on R_C)

$R_o = r_o \| R_C$

$|A_v| = |-g_m (r_o \| R_C)|$

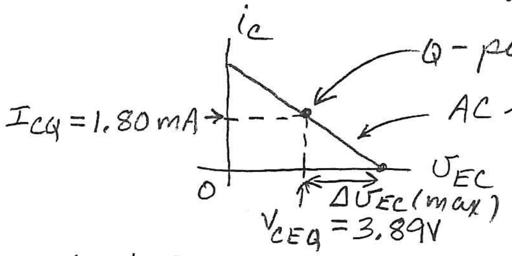
(Increase)





P) A common-emitter amplifier is constructed using a 12 V dc power supply and a pnp BJT. At the quiescent point, $V_{EC} = 3.89$ V and $I_C = 1.80$ mA. If the slope of the circuit's ac load line is −1 / 1.83 kΩ, which of the following is closest to the maximum symmetrical swing in the output voltage?

a: 7 V
b: 8 V
c: 9 V
d: 10 V
e: 11 V



$$\left(slope = \frac{-1}{1.83\,k\Omega} = \frac{-I_{CQ}}{\Delta v_{EC}(max)}\right)$$

$$\Delta v_{EC}(max) = \left(\frac{-1}{slope}\right)(I_{CQ}) = (1.83\,k\Omega)(1.80\,mA) = 3.294\,V$$

Maximum symmetrical swing $= 2\Delta v_{EC}(max) = 6.588$ V

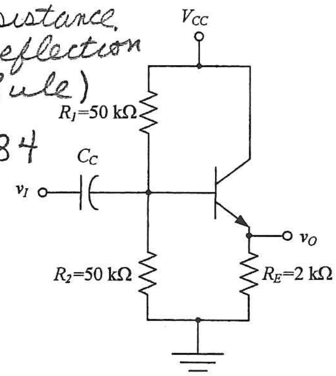
Q) For the transistor in the circuit below, $\beta = 100$, $V_A = \infty$, $g_m = 30.5$ mA/V, and $r_\pi = 3.28$ kΩ. Which of the following is closest to the small-signal, ac voltage gain of the circuit?

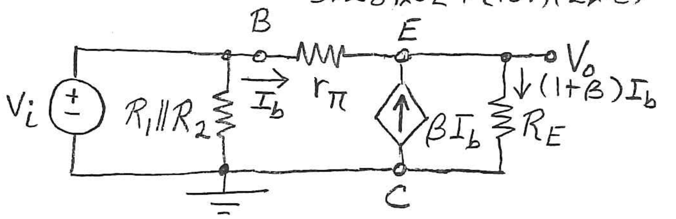
a: 0.90
b: 0.92
c: 0.94
d: 0.96
e: 0.98

$$A_v = \frac{V_o}{V_i} = \frac{(1+\beta)\cancel{I_b} R_E}{\cancel{I_b}[r_\pi + (1+\beta)R_E]}$$

(Resistance Reflection Rule)

$$= \frac{(101)(2\,k\Omega)}{3.28\,k\Omega + (101)(2\,k\Omega)} \cong 0.984$$

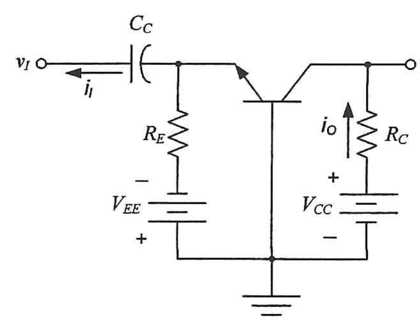




R) Which of the following are typical properties of the type of circuit below?

a: Large input resistance and large output resistance
b: Large input resistance and small output resistance
c: Small input resistance and large output resistance
d: Small input resistance and small output resistance
e: None of the above

Common-base amplifier
See text sec. 6.7



S) An engineer needs to design a single-transistor amplifier whose small-signal, ac current gain is 20. If the amplifier's input and output resistances are not important for this application, which of the following kinds amplifiers might be suitable?

a: Only common-base
b: Either common-emitter or common-collector
c: Either common-base or common-emitter
d: Either common-base or common-collector
e: None of the above

See text sec. 6.8

For common-emitter and common-collector, $A_i > 1$
For common-base, $A_i \cong 1$

T) For the amplifier below, $V_{CC} = 10$ V, $R_C = 3.0$ kΩ, and the quiescent collector current is 2.0 mA. If the power dissipated by the bias resistors is negligible, which of the following is closest to the total average power delivered to the circuit by the power supply?

a: 0 mW
b: 5 mW
c: 10 mW
d: 15 mW
e: 20 mW

Average power delivered by Vcc

$= V_{CC} I_{CQ}$

$= (10\,V)(2.0 \times 10^{-3}\,A) = 0.02\,W$