Question #1: (20 Points)

Choose the right answer:

1) In a voltage-divider biased npn transistor, if the lower voltage-divider resistor (the one connected to ground) opens,

   D (A) the transistor is not affected
   (B) the transistor may be driven into cutoff
   (C) the collector current will decrease
   (D) the transistor may be driven into saturation

2) A differential amplifier

   D (A) is used in op-amps
   (B) has one input and one output
   (C) has two outputs
   (D) answers (A) and (C)

3) A MOSFET differs from a JFET mainly because

   C (A) of the power rating
   (B) the MOSFET has two gates
   (C) the JFET has a pn junction
   (D) MOSFETs do not have a physical channel

4) The efficiency of a power amplifier is the ratio of the power delivered to the load to the

   B (A) input signal power
   (B) power from the dc power supply
   (C) power dissipated in the transistor
   (D) power dissipated in the last stage

5) When operated in cutoff and saturation, the transistor acts like a

   B (A) linear amplifier
   (B) switch
   (C) variable capacitor
   (D) variable resistor

6) In saturation, $V_{CE}$ is

   C (A) 0.7 V
   (B) equal to $V_{CC}$
   (C) minimum
   (D) maximum

7) A certain common-emitter amplifier has a voltage gain of 100. If the emitter bypass capacitor is removed,

   B (A) the circuit will become unstable
   (B) the voltage gain will decrease
   (C) the voltage gain will increase
   (D) the Q-point will shift

8) A differential amplifier

   D (A) is used in op-amps
   (B) has one input and one output
   (C) has two outputs
   (D) answers (a) and (c)

9) The peak current a class A power amplifier can deliver to a load depends on the

   B (A) maximum rating of the power supply
   (B) quiescent current
   (C) current in the bias resistors
   (D) size of the heat sink

10) If the gate-to-source voltage in an n-channel E-MOSFET is made more positive, the drain current will

    A (A) increase
    (B) remain unchanged
    (C) decrease
**Question #2: (10 Points)**

a) A certain transistor has $\alpha_{DC} = 0.99$. If the dc base current is 10 $\mu$A, determine $r_e'$. 

\[
\beta = \frac{\alpha}{1-\alpha} = 99 \\
I_E = (\beta + 1)I_B = 1 \text{ mA} \\
r_e' = \frac{25}{I_E} = 25 \Omega
\]

b) A common-emitter amplifier is driving a load resistance $R_L = 10 \text{ k}\Omega$. If $R_C = 2.2 \text{ k}\Omega$, $I_{CQ} = 2.5\text{mA}$, $\beta_{ac} = 75$ and $R_E$ is completely bypassed at the operating frequency. Find the voltage gain.

\[
r_e' = \frac{25}{I_E} = 10 \Omega \\
R_C' = \frac{2.2}{10} = 1.8 \text{ K}\Omega \\
A_v = -\frac{R_C'}{r_e'} = -180
\]

c) An n-channel JFET has $I_{DSS} = 5 \text{ mA}$ and $V_{GS(off)} = -8 \text{ V}$. What value of $V_{GS}$ is required to set up a drain current of 2.25 mA.

\[
I_D = 5[1 - V_{GS}/(-8)]^2 = 2.25 \\
V_{GS} = -2.63 \text{ V}
\]

d) Each stage of a four-stage amplifier has a voltage gain of 15. Find the overall voltage gain in dBs.

\[
A_v = 94.09 \text{ dBs}
\]

e) An n-channel E-MOSFET has $I_{D(on)} = 18 \text{ mA}$ at $V_{GS} = 4 \text{ V}$, and $V_{GS(th)} = 2.5 \text{ V}$. Find $I_D$ when $V_{GS} = 3.25 \text{ V}$.

\[
K = 8 \text{ mA/V}^2 \\
I_D = 4.5 \text{ mA}
\]
Question #3: (10 Points)
The silicon npn transistor used in the swamped amplifier shown in Fig.3 has $\beta_{dc} = \beta_{ac} = 100$.
   a) Find $I_{CQ}$ and $V_{CEQ}$.
   b) Find $r'_e$.
   c) Find the voltage gain and input impedance of the amplifier.

\[
\begin{align*}
I_{CQ} &= 0.295 \text{ mA} \\
V_{CEQ} &= 6.45 \text{ V} \\
r'_e &= 84.6 \Omega
\end{align*}
\]
\[
A_v = -7.6 \\
Z_{in} = 23.75 \text{ K}\Omega
\]

Question #4: (12 Points)
The silicon npn transistor used in the common base amplifier of Fig.4 has $\beta_{dc} = \beta_{ac} = 250$.
   a) Find $I_{CQ}$ and $V_{CEQ}$. (4 Points)
   b) Find $r'_e$. (2 Point)
   c) Find the voltage gain, current gain and input impedance of the circuit. (6 Points)

\[
\begin{align*}
I_{CQ} &= 1.02 \text{ mA} \\
V_{CEQ} &= 6.74 \text{ V} \\
r'_e &= 24.5 \Omega
\end{align*}
\]
\[
A_v = 89.8 \\
A_i = 1 \\
Z_{in} = 24.5 \Omega
\]

Question #5: (5 Points)
a) A certain JFET datasheet gives $I_{DSS} = 10 \text{ mA}$ and $V_{GS(off)} = -8 \text{ V}$. Determine the drain current for $V_{GS} = -5 \text{ V}$. (2 Points)

\[
I_D = 1.41 \text{ mA}
\]

b) The transistor is to operate at: $V_{GSQ} = -5 \text{ V}$, $V_{DSQ} = 10\text{ V}$. Draw a suitable circuit to bias this transistor giving suitable resistances values, assuming that $V_{DD} = 24 \text{ V}$ (3 Points)
Question #6: (8 Points)
The class AB amplifier in Fig.6 is operating with a single power supply.

(a) Assuming the input voltage is 10 V peak-to-peak, determine the power delivered to the load resistor. (3 Points)
(b) What is the maximum power that could be delivered to the load resistor? (3 Points)
(c) Assume the power supply voltage is raised to 24 V. What is the new maximum power that could be delivered to the load resistor? (2 Points)

\[ P_{LD} = 0.25 \text{ W} \]
\[ P_{LD(max)} = \frac{0.5625 \text{ W}}{\text{For } V_{CC}=15\text{V}} \]
\[ P_{LD(max)} = 1.44 \text{ W} \]

Question #7: (8 Points)
The following parameters are obtained from a certain JFET datasheet: \( I_{DSS} = 5 \text{ mA} \) and \( V_{GS(off)} = -8 \text{ V} \). Determine the values of \( I_D \) for each value of \( V_GS \) ranging from 0 V to -8 V in 1 V steps. Plot the transfer characteristic curve from these data.

\[
\begin{array}{|c|c|c|c|c|c|c|c|}
\hline
V_{GS}/\text{volts} & 0 & -1 & -2 & -3 & -4 & -5 & -6 & -7 & -8 \\
\hline
I_D/\text{mA} & 5 & 3.8 & 2.8 & 2 & 1.25 & 0.7 & 0.31 & 0.08 & 0 \\
\hline
\end{array}
\]

Question #8: (12 Points)
The E-MOSFET used in the common-source amplifier in Fig.8 has \( I_{D(on)} = 200 \text{ mA} \) at \( V_GS = 4 \text{ V} \) and \( V_{GS(th)} = 2 \text{ V} \).

a) Determine the operating point \( V_{GSQ}, I_{DQ} \) and \( V_{DSQ} \). (6 Points)
b) Calculate the value of the transconductance \( g_m \) at the \( Q \)-point (2 Points)
c) Determine the voltage gain and input impedance of the amplifier. (4 Points)

\[ V_{GSQ} = 2.5 \text{ V} \]
\[ I_{DQ} = 12.5 \text{ mA} \]
\[ V_{DSQ} = 2.5 \text{ V} \]
\[ g_m = 50 \text{ mS} \]
\[ A_v = -48.5 \]
\[ Z_{in} = 250 \text{ K}\Omega \]
**Question #9: (15 Points)**

For the amplifier circuit of Fig. 9, determine the critical frequencies \((f_{L1}, f_{L2}, f_{L3})\) associated with the low-frequency response, the critical frequencies \((f_{H1}, f_{H2})\) associated with the high-frequency response.

\[
\beta_{dc} = \beta_{ac} = 100, \ h_{ie} = 900 \Omega, \ r_e' = 9 \Omega, \ C_{be} = 25 \text{pF}, \ C_{bc} = 10 \text{pF}, \ R_s = 600 \Omega, \ R_1 = 68 \text{K}\Omega, \ R_2 = 18 \text{K}\Omega, \ R_E = 500 \Omega, \ R_C = 1.8 \text{K}\Omega, \ R_L = 1.8 \text{K}\Omega, \ C_1 = 0.5 \mu\text{F}, \ C_2 = 10 \mu\text{F}, \ C_3 = 1 \mu\text{F}.
\]

\[
\begin{align*}
C &= C_1 = 0.5 \mu\text{F} \\
R &= (R_1 // R_2 // h_{ie}) + R_s = 1.446 \text{K}\Omega \\
f_{L1} &= \frac{10^6}{2\pi \times 0.5 \times 1446} = 220 \text{Hz} \\
f_{L1} &= 220 \text{Hz}
\end{align*}
\]

\[
\begin{align*}
C &= C_2 = 10 \mu\text{F} \\
R &= (R_1 // R_2 // h_{ie}) / h_{fe} \times R_E = 14.4 \Omega \\
f_{L1} &= \frac{10^6}{2\pi \times 10 \times 14.4} = 1112 \text{Hz} \\
f_{L2} &= 1112 \text{Hz}
\end{align*}
\]

\[
\begin{align*}
C &= C_3 = 1 \mu\text{F} \\
R &= (R_C + R_s) = 3.6 \text{K}\Omega \\
f_{L1} &= \frac{10^6}{2\pi \times 1 \times 3600} = 44 \text{Hz} \\
f_{L3} &= 44 \text{Hz}
\end{align*}
\]

\[
\begin{align*}
C_{in} &= C_{be} + (A_v + 1) C_{bc} = 1035 \text{pF} \\
R_{in} &= (R_1 // R_2 // h_{ie} // R_s) = 351 \Omega \\
f_{L1} &= \frac{10^{12}}{2\pi \times 1035 \times 351} = 438 \text{KHz} \\
f_{H1} &= 438 \text{KHz}
\end{align*}
\]

\[
\begin{align*}
C_{in} &= C_{bc} = 10 \text{pF} \\
R_{out} &= (R_c // R_1) = 900 \Omega \\
f_{L1} &= \frac{10^{12}}{2\pi \times 10 \times 900} = 17.7 \text{MHz} \\
f_{H2} &= 17.7 \text{MHz}
\end{align*}
\]