1. For JFETs operating in pinch-off mode, the drain current is as follow: \( i_D = I_{DSS} \left( 1 - \frac{V_{GS}}{V_p} \right) \)

where \( V_p \) is the pinch-off voltage.

(a) Please show that the small signal transconductance which is defined as \( g_m = \frac{i_d}{v_{gs}} \) is approximately \( \frac{2I_{DSS}}{|V_p| \sqrt{I_{DSS}}} \). \( (7\%) \)

(b) In the circuit shown in Figure 1, assume the JFET has \( I_{DSS} = 8\text{mA} \) and \( V_p = -2\text{V} \).

Find the DC current \( I_D \), the small signal transconductance \( g_m \), and the voltage gain \( \frac{v_o}{v_i} \). \( (8\%) \)

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![Figure 1](image-url)
2. For BJT's shown in Figure 2, $|V_{CE}|$ is 0.3 V for saturation mode and $|V_{BE}|$ is 0.7 for both active mode and saturation mode.

(a) Find the DC operation point ($V_B$, $V_C$, and $V_E$) of the circuit shown in Figure 2(a) and Figure 2(b).

(b) Find the $r_s$, $\frac{v_{ol}}{v_i}$, $\frac{v_o}{v_i}$ for Figure 2(b).

3. Please express the output $v_o$ in terms of $v_1$, $v_2$, $R_1$, $R_2$, $R_3$ and $R_4$ for the circuit shown in Figure 3 (suppose the OP amplifier is ideal).
In Fig. 4, the op-amp circuit has three internal critical frequencies as follows: 1.2KHz, 50KHz, and 250KHz. If the midrange open-loop gain is 100dB, is the amplifier configuration stable, marginally stable, or unstable? (10%)

Fig. 4

In Fig. 5, the 1N4744 zener used in the regulator circuit. The data sheet gives the following information: \(V_Z=15V\) @ \(I_{ZT}=17mA\), minimum current value \(I_{ZK}=0.25mA\), zener impedance \(Z_{ZT}=14\Omega\), and the maximum power dissipation \(P_{D(max)}=1W\).

(a). What is the maximum current value \((I_{ZM})\)? (4%)  
(b). Determine \(V_{OUT}\) at \(I_{ZK}\) and at \(I_{ZM}\). (4%)  
(c). Calculate the value of \(R\) that should be used. (4%)  
(d). Determine the \(R_{L(min)}\) that can be used. (4%)  

Fig. 5
Th JFET amplifier shows in Fig. 6. The Data sheet gives the following information: the gate reverse current $I_{GS}=100 \text{nA}$ at $V_{GS}=-10 \text{V}$, the input capacitance $C_{iss}=8 \text{pF}$, the reverse transfer capacitance $C_{rs}$, the transconductance $g_m=65000 \text{ \mu S}$

(a). What are the capacitor values of $C_{gd}$ and $C_{gs}$? (3%)
(b). What is the midrange voltage gain ($V_{out} / V_{in}$)? (3%)
(c). Find the critical frequencies of the high-frequency input and output RC circuit for the amplifier.
(d). Find the critical frequencies of the low-frequency input and output RC circuit for the amplifier.
(e). What is the bandwidth of the amplifier. (4%)

7. Given the transfer function

$$H(jw) = 50 \frac{jw(1 + j \frac{w}{10})}{(1 + j \frac{w}{10^4})(1 + j \frac{w}{10^7})}$$

(a). What is Bode plot of the voltage gain and phase? (8%)
(b). If $w = 10^7$. Determine the dB value of voltage gain? (6%)