

ECE4902 N-CHANNEL MOSFET OPERATING REGIONS

GATE	DRAIN	REGION	FIRST ORDER BEHAVIOR	NOT EXACTLY:
$V_{GS} > V_{TH}$	$V_{DS} > V_{GS} - V_{TH}$	SATURATION	DRAIN "LOOKS LIKE" CURRENT SOURCE; I_D DEPENDS ONLY ON $V_{GS} - V_{TH}$ $I_D = \frac{\mu_n C_{ox}}{2} \frac{W}{L} (V_{GS} - V_{TH})^2$	CHANNEL LENGTH MODULATION I_D DEPENDS SOMEWHAT ON V_{DS} $I_D = \frac{\mu_n C_{ox}}{2} \frac{W}{L} (V_{GS} - V_{TH})^2 [1 + \lambda V_{DS}]$
	$V_{DS} < V_{GS} - V_{TH}$	TRIODE	D-S CHANNEL "LOOKS" RESISTIVE $I_D = V_{DS} / R_{on}$ R_{on} DEPENDS ON $V_{GS} - V_{TH}$ $R_{on} = \frac{1}{\mu_n C_{ox} \frac{W}{L} (V_{GS} - V_{TH})}$	NONLINEAR AS V_{DS} INCREASES $I_D = \mu_n C_{ox} \frac{W}{L} \left[(V_{GS} - V_{TH}) V_{DS} - \frac{V_{DS}^2}{2} \right]$
$V_{GS} < V_{TH}$	$ V_{DS} < V_{bkd}$	CUTOFF	SWITCH "OFF" $I_D = 0$	$I_D \approx$ pA to nA SUBTHRESHOLD CURRENT BREAKDOWN IF $ V_{DS} $ EXCEEDS V_{bkd}

ECE4902 P-CHANNEL MOSFET OPERATING REGIONS

GATE	DRAIN	REGION	FIRST ORDER BEHAVIOR	NOT EXACTLY:
$V_{GS} < V_{TH}$	$V_{DS} < V_{GS} - V_{TH}$	SATURATION	DRAIN "LOOKS LIKE" CURRENT SOURCE; I_D DEPENDS ONLY ON $V_{GS} - V_{TH}$ $I_D = -\frac{\mu_p C_{ox}}{2} \frac{W}{L} (V_{GS} - V_{TH})^2 [1 + \lambda V_{DS}]$	CHANNEL LENGTH MODULATION I_D DEPENDS SOMEWHAT ON V_{DS} $I_D = -\frac{\mu_p C_{ox}}{2} \frac{W}{L} (V_{GS} - V_{TH})^2 [1 + \lambda V_{DS}]$
	$V_{DS} > V_{GS} - V_{TH}$	TRIODE	D-S CHANNEL "LOOKS" RESISTIVE $I_D = V_{DS} / R_{on}$ R_{on} DEPENDS ON $V_{GS} - V_{TH}$ $R_{on} = \frac{1}{\mu_n C_{ox} \frac{W}{L} (V_{GS} - V_{TH})}$	NONLINEAR AS V_{DS} INCREASES $I_D = -\mu_p C_{ox} \frac{W}{L} \left[(V_{GS} - V_{TH}) V_{DS} - \frac{V_{DS}^2}{2} \right]$
$V_{GS} > V_{TH}$	$ V_{DS} < V_{bkd}$	CUTOFF	SWITCH "OFF" $I_D = 0$	$I_D \approx$ pA to nA SUBTHRESHOLD CURRENT BREAKDOWN IF $ V_{DS} $ EXCEEDS V_{bkd}