Fundamentals of Electronics
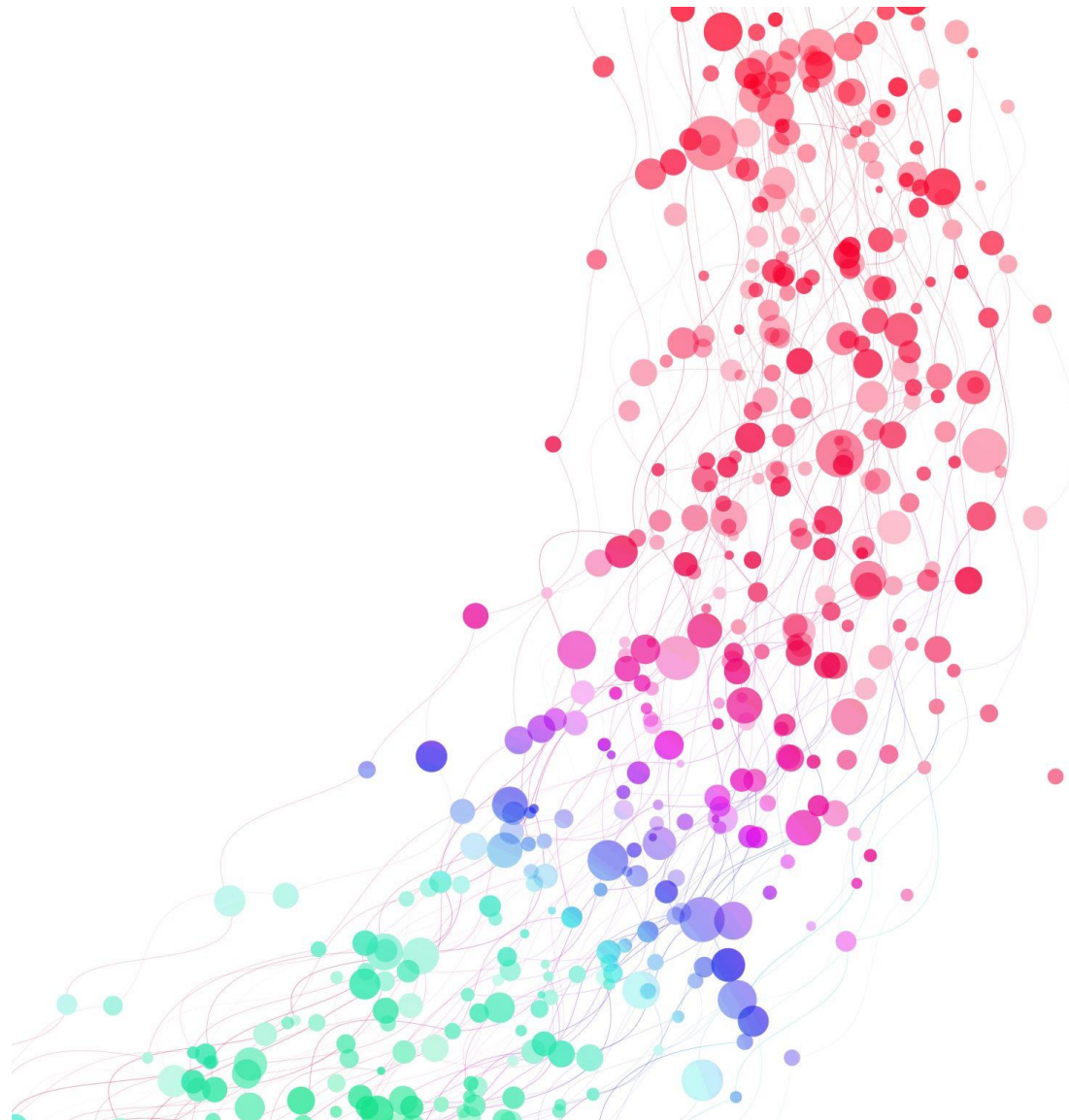
# ECE 101

The Transistor

Transistor

- Key characteristic:

  - The transistor is a three-terminal device with the feature that the <u>current through two terminals can be controlled by small changes we make in the current or voltage at the third terminal</u>.

  - This control feature allows us to <u>amplify small ac signals</u> or to <u>switch the device from an *on* state to an *off* state and back</u>.

  - These two operations, <u>*amplification* and *switching*</u>, are the basis of a host of electronic functions.

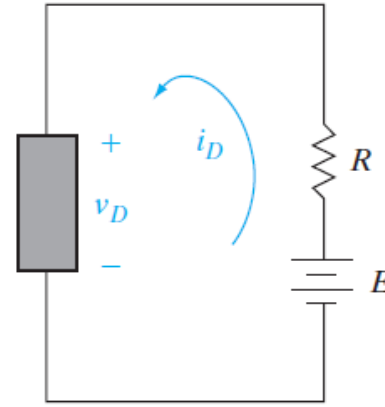 - This forms the basis for both <u>bipolar junction transistors (BJT)</u> and <u>field effect transistors (FET)</u>.

The transistor action - 1
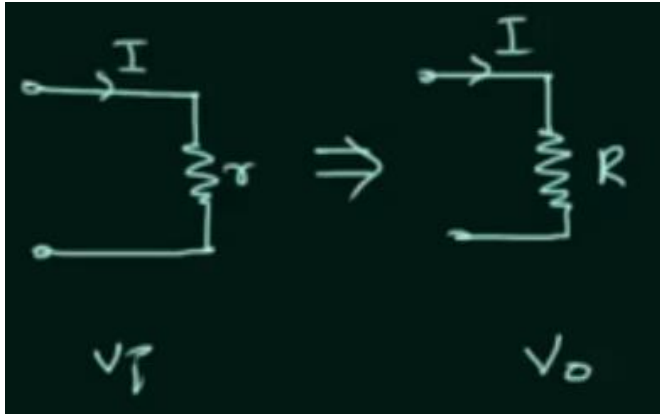
$$v_i = I \times r$$

$$V_o = I \times R$$

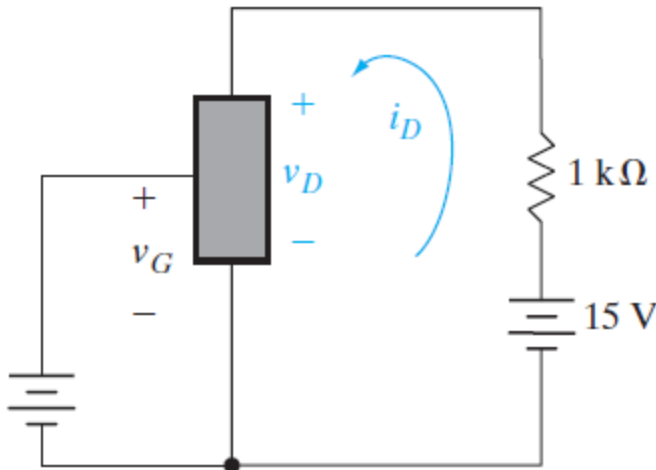$$v_i < v_o \quad (amplification)$$

Active mode

$J_1 \rightarrow$ f.b.   Res = 0

$J_2 \rightarrow$ r.b.   Res = ∞

BJT

The transistor action - 2

$$i_D = f(V_D)$$
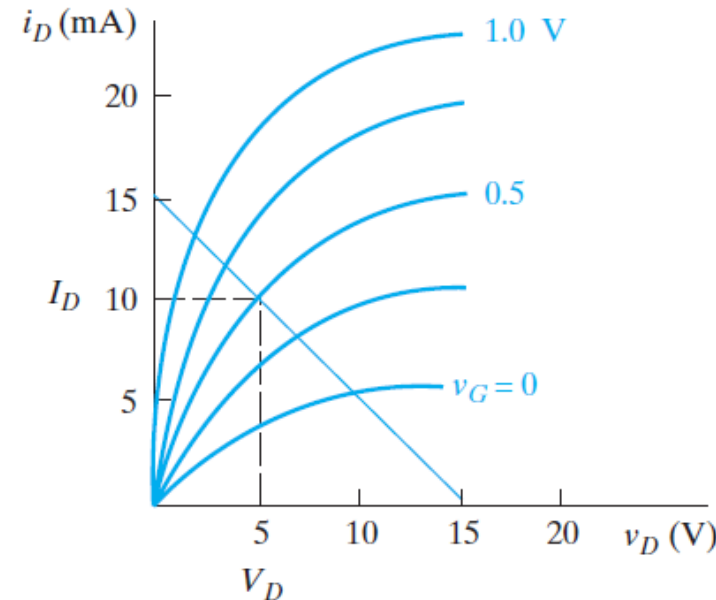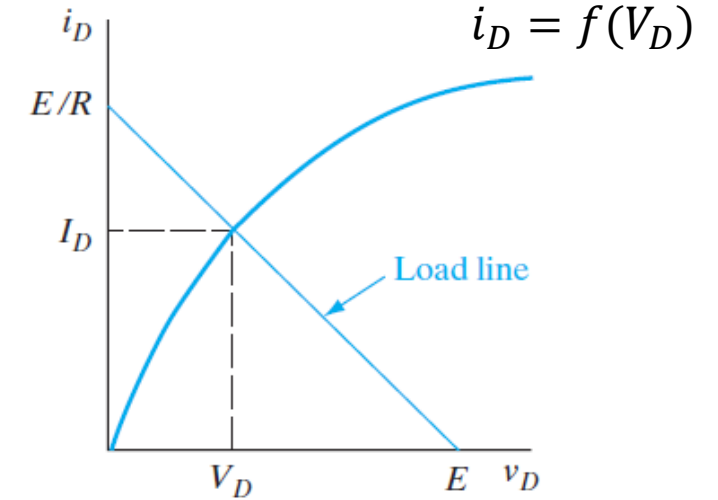
- If an ac source is added to the control voltage
  - We can achieve large variations in iD by making small changes in VG
  - For example if VG changes by value of 0.25V, Vd varies about its dc 2V.
  - Thus the amplification of the ac signal is 2/0.25 = 8.
  - we can switch from the bottom of the load line to almost the top by appropriate changes in V_G.

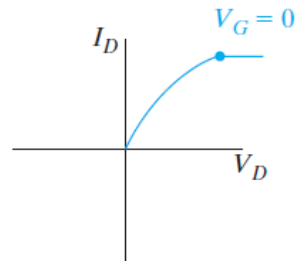**For BJTs, this kind of control is achieved by current control.**
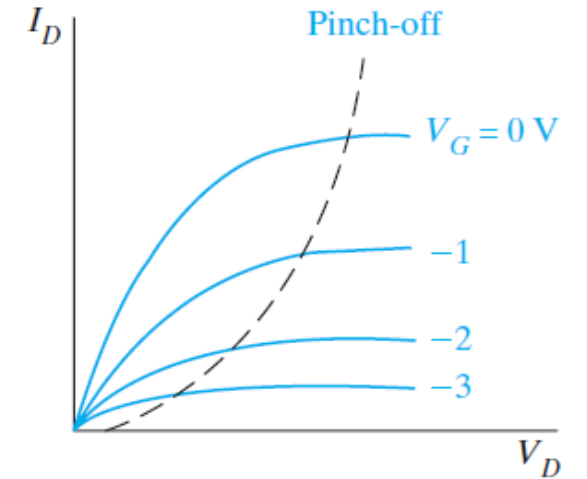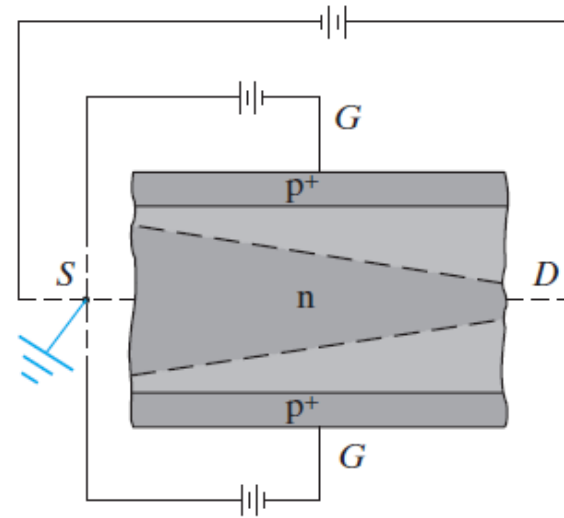
Field Effect Transistors

The idea

Junction Field Effect Transistor: JFETs
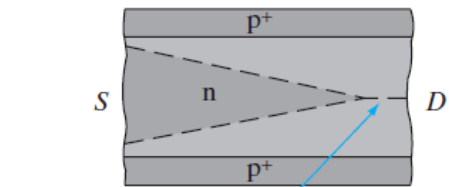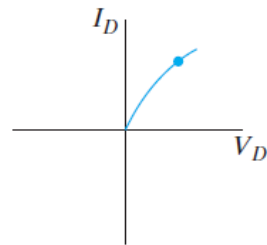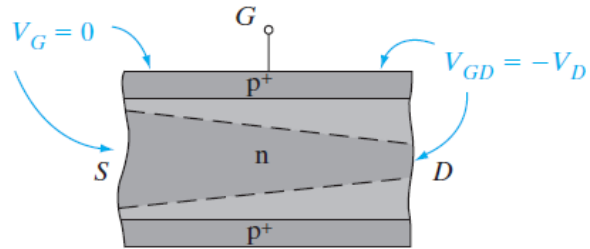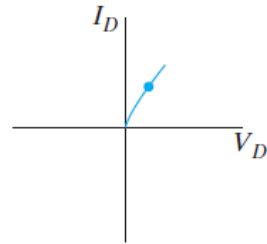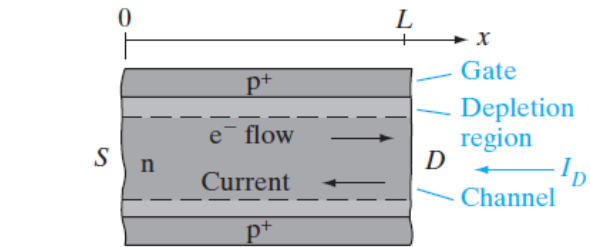
$$v_d = \frac{I}{neA}$$
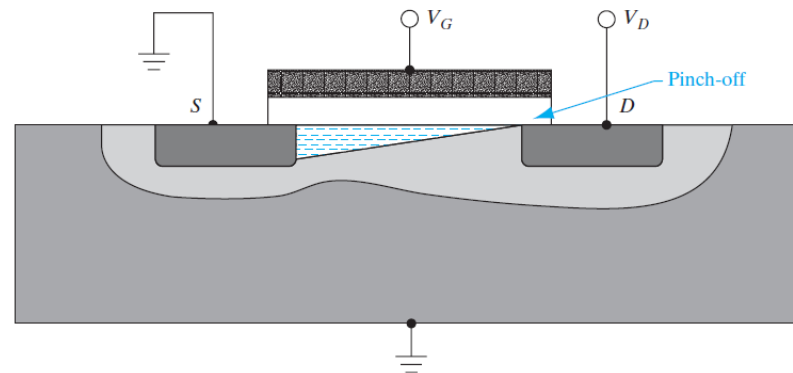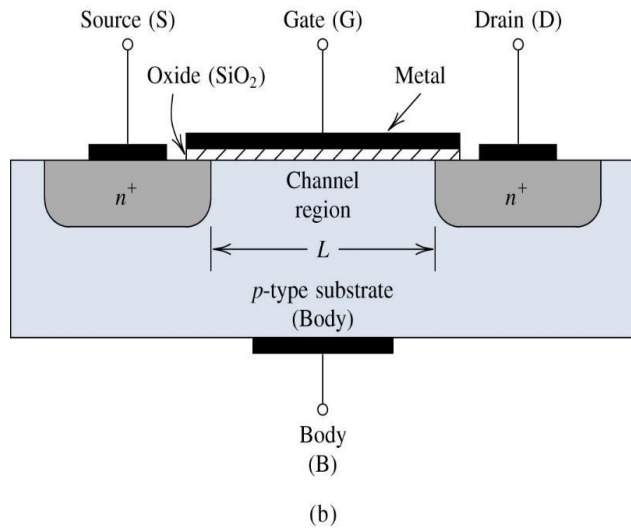
Gate control

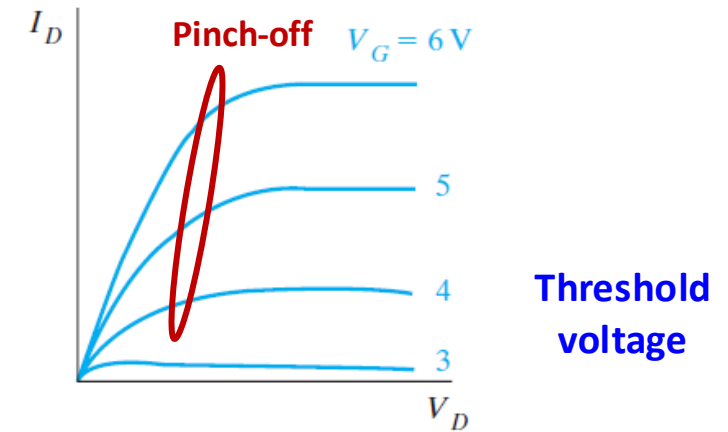# MOSFET (Metal–Oxide–Semiconductor Field-Effect Transistor)
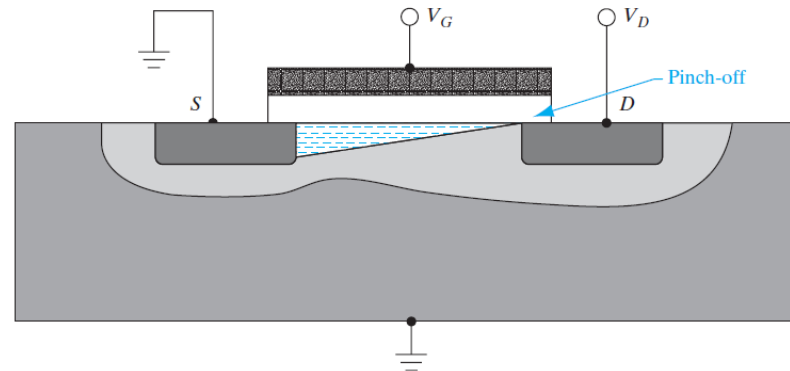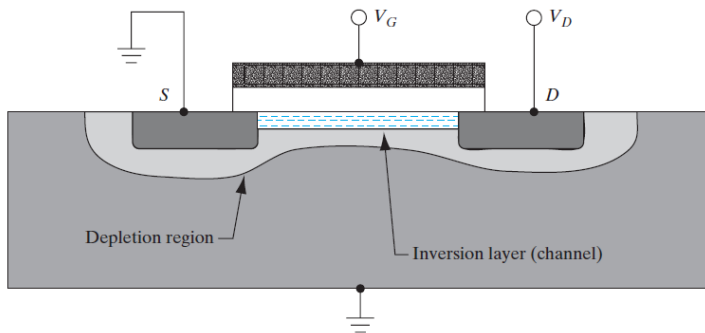
MOSFET

Different regimes as V$_D$ is varied.

Field Effect Transistors

Source (S) Gate (G) Drain (D)

Oxide (SiO$_2$) Metal

n^+ Channel region n^+

L

p-type substrate (Body)

Body (B)

(b)

Characteristics

S G D

n^+ n^+

p

I_D **Pinch-off** $V_G = 6$ V

5

4 **Threshold voltage**

3

V_D

Different regimes as V$_D$ is varied.

V_G V_D

S D

Depletion region Inversion layer (channel)

V_G V_D

Pinch-off

S D

Pinch-off

Pinch-off

V_G V_D

S D

Thank you