6.002 CIRCUITS AND ELECTRONICS

Nonlinear Analysis

Review

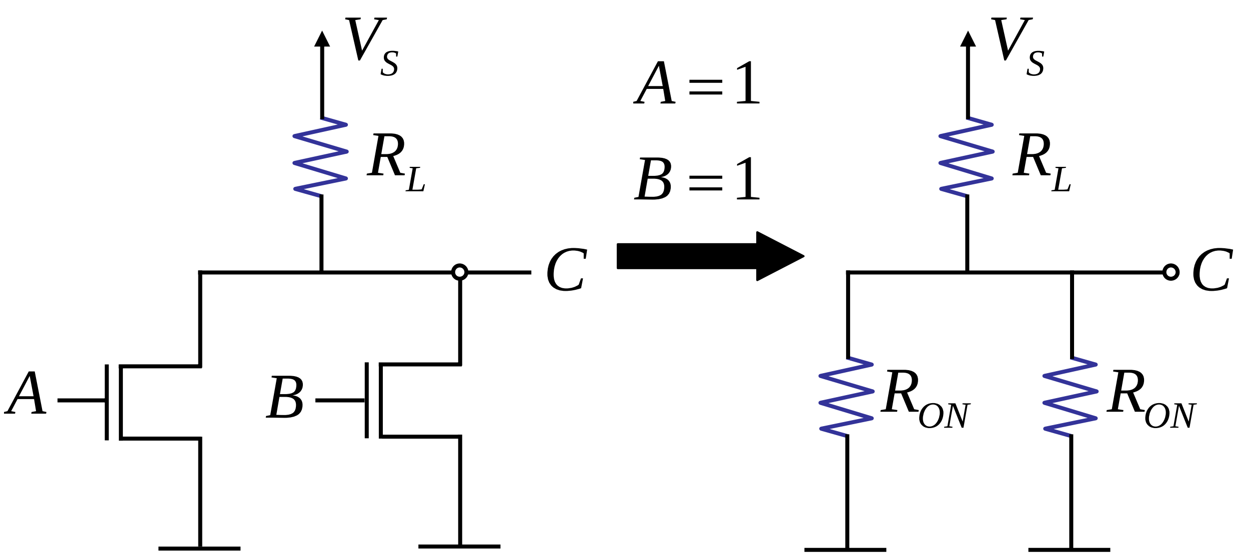
- Discretize matter → LCA

m1 ▶ KVL, KCL, *i-v*
m2 ▶ Composition rules
m3 ▶ Node method
} any circuit

m4 ▶ Superposition
m5 ▶ Thévenin, Norton
} linear circuits

Review

- Discretize value → Digital abstraction
  - Subcircuits for given "switch" setting are linear! So, all 5 methods (m1 - m5) can be applied

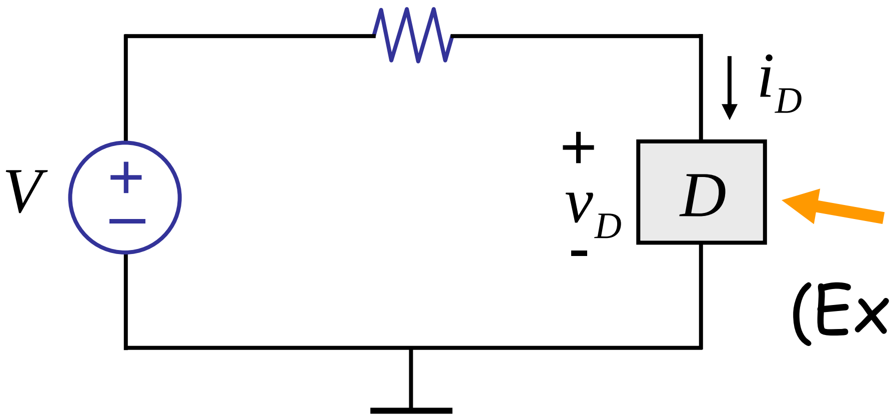


SR MOSFET Model

Today

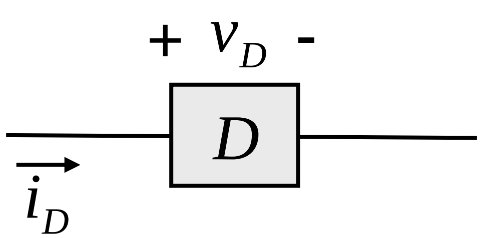
- Nonlinear Analysis
  - Analytical method based on m1, m2, m3
  - Graphical method
  - Introduction to incremental analysis

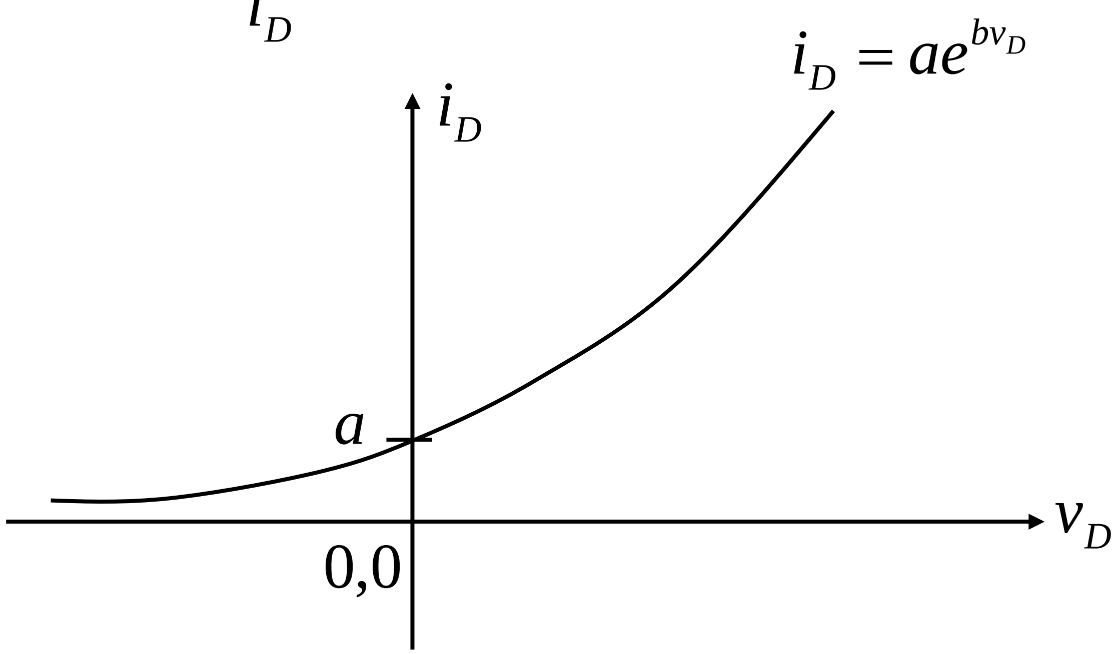
How do we analyze nonlinear circuits, for example:



Hypothetical nonlinear device

(Expo Dweeb ☺)





(Curiously, the device supplies power when v_D is negative)

Method 1: Analytical Method

Using the node method,
(remember the node method applies for linear or nonlinear circuits)

$$\frac{v_D - V}{R} + i_D = 0 \qquad (1)$$

$$i_D = ae^{bv_D} \qquad (2)$$

2 unknowns   2 equations

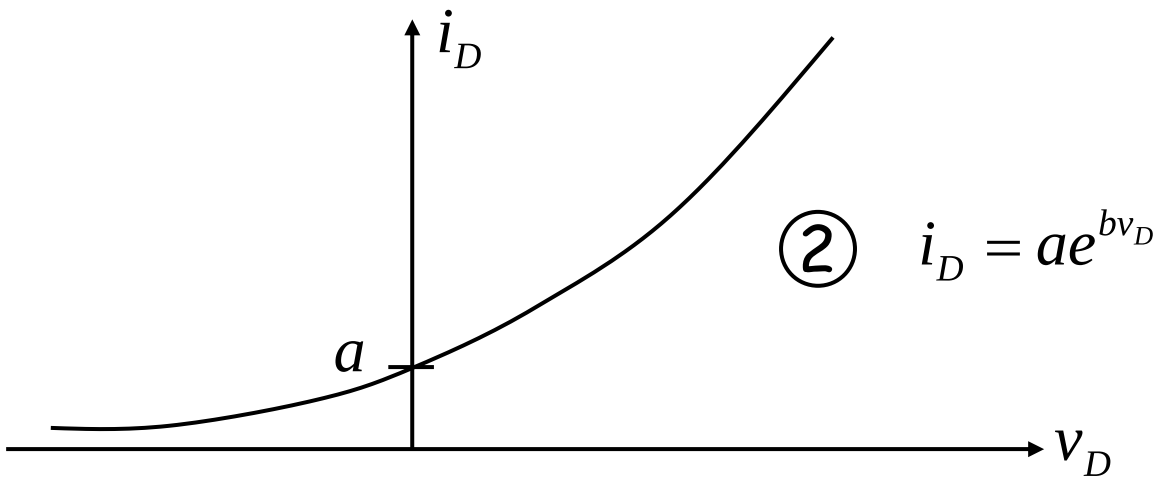
Solve the equation by

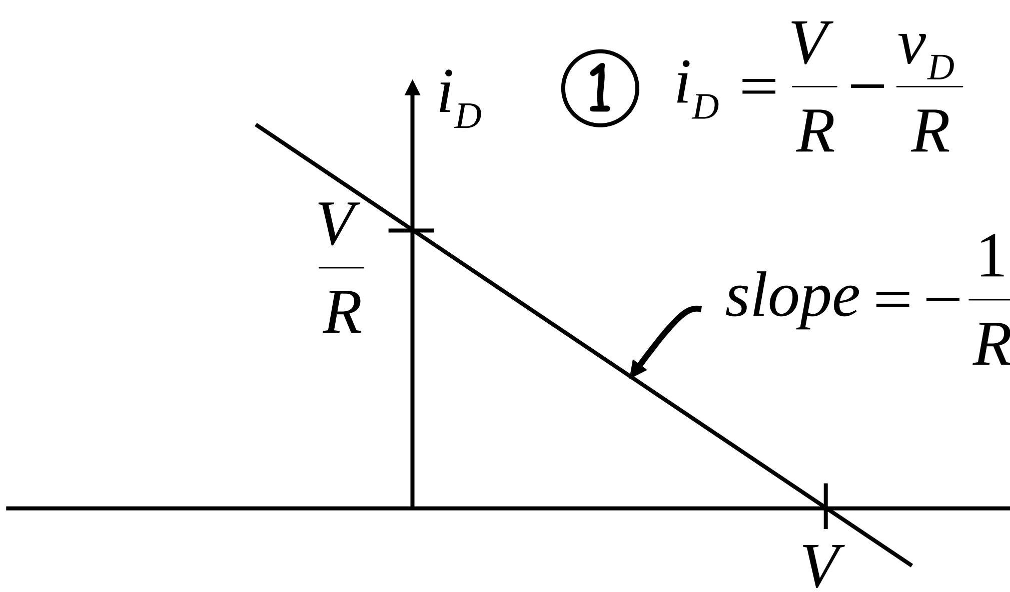
- trial and error
- numerical methods

Method 2: Graphical Method

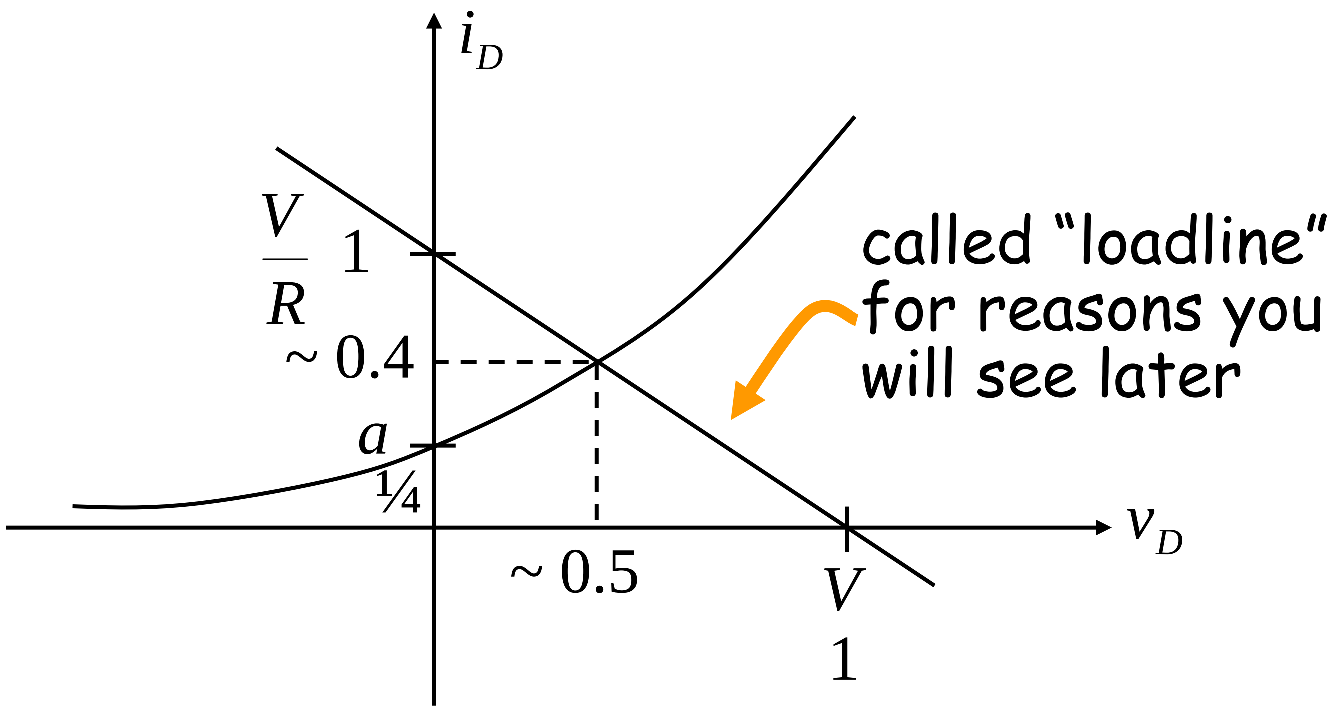
Notice: the solution satisfies equations

① and ②





Combine the two constraints



e.g. $V = 1$ $\quad v_D = 0.5V$

$R = 1$ $\quad i_D = 0.4A$

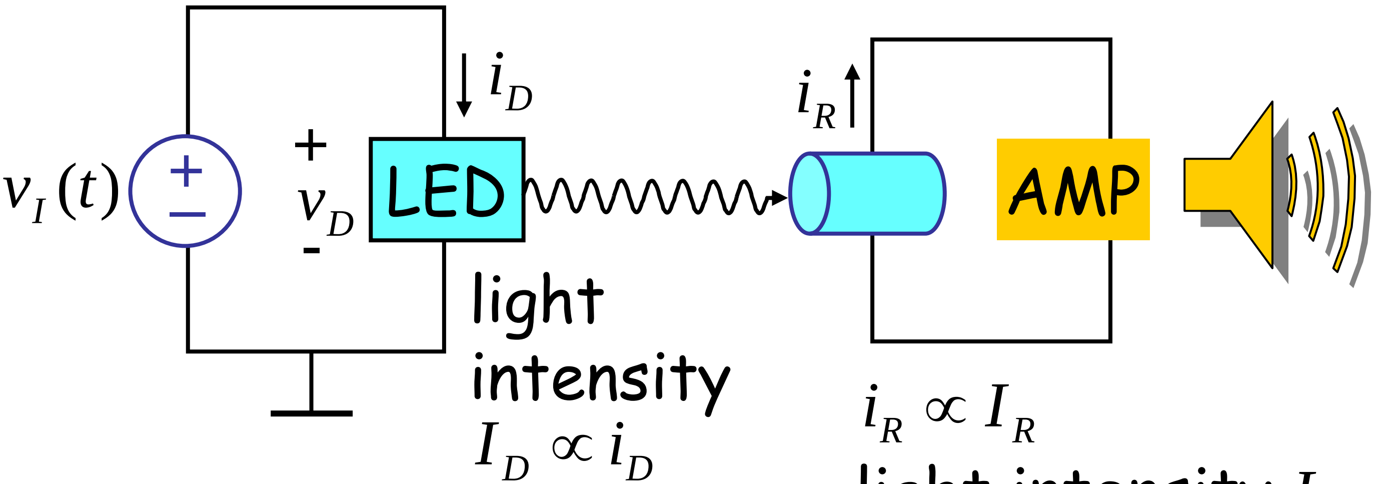
$a = \frac{1}{4}$

$b = 1$

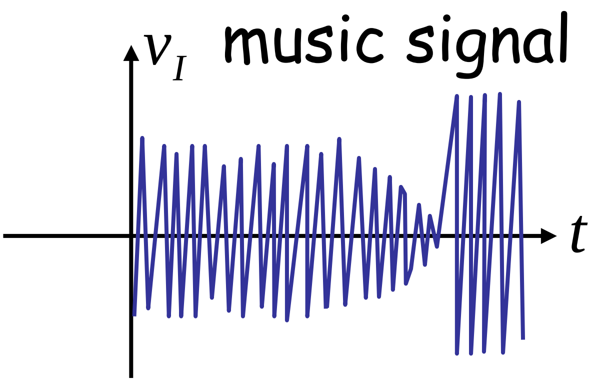
Method 3: Incremental Analysis

Motivation: music over a light beam

Can we pull this off?



light intensity I_R in photoreceiver



LED: Light Emitting expoDweep ☺

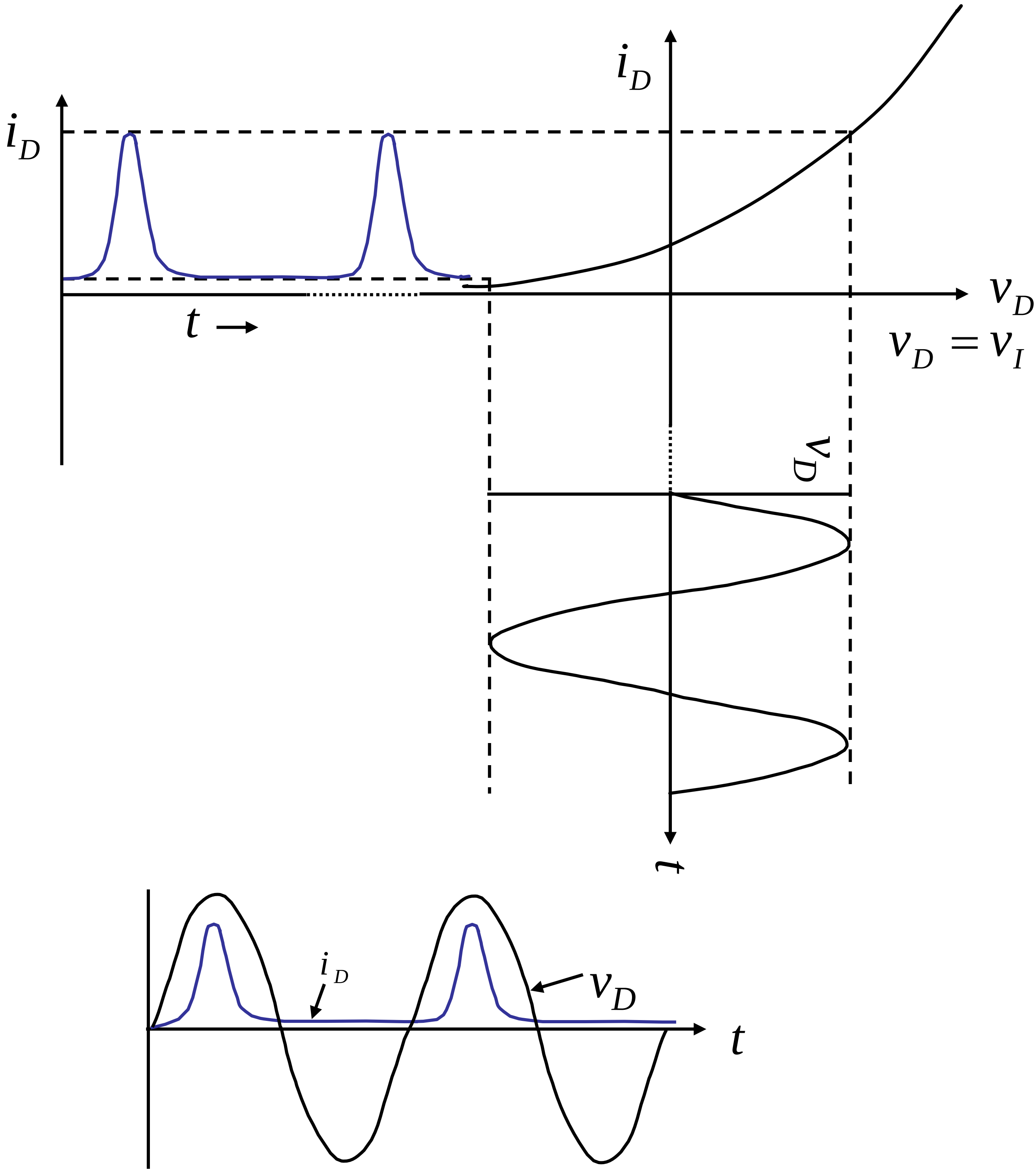
$v_I(t) \longrightarrow i_D(t)$ ⇝ light ⇝ $i_R(t) \longrightarrow$ sound

nonlinear: $v_I(t) \longrightarrow i_D(t)$

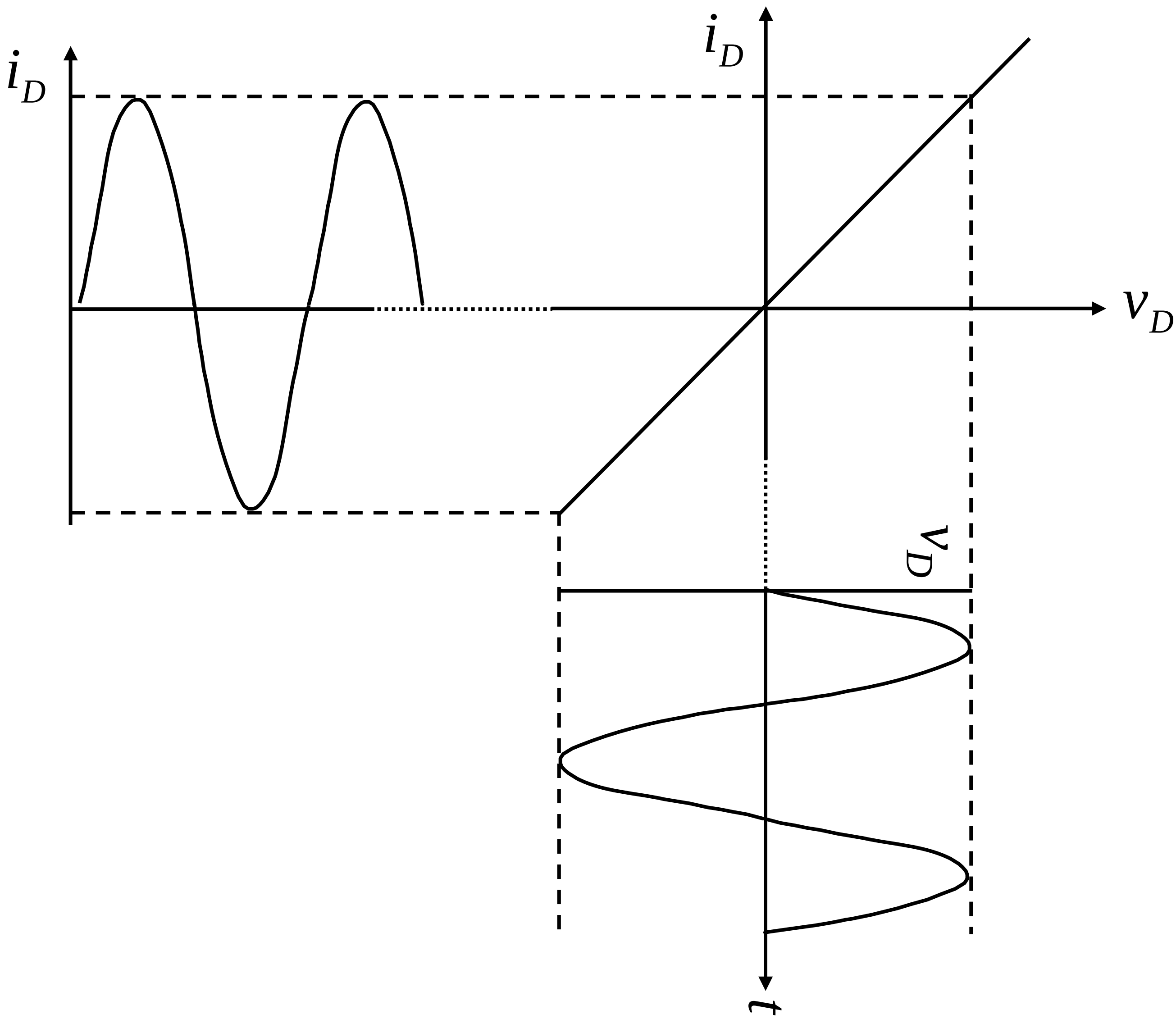
linear: $i_D(t)$ ⇝ light ⇝ $i_R(t) \longrightarrow$ sound

nonlinear → problem! will result in distortion

Problem:
The LED is nonlinear ➡ distortion



If only it were linear …



it would've been ok.

What do we do?

Zen is the answer

… next lecture!