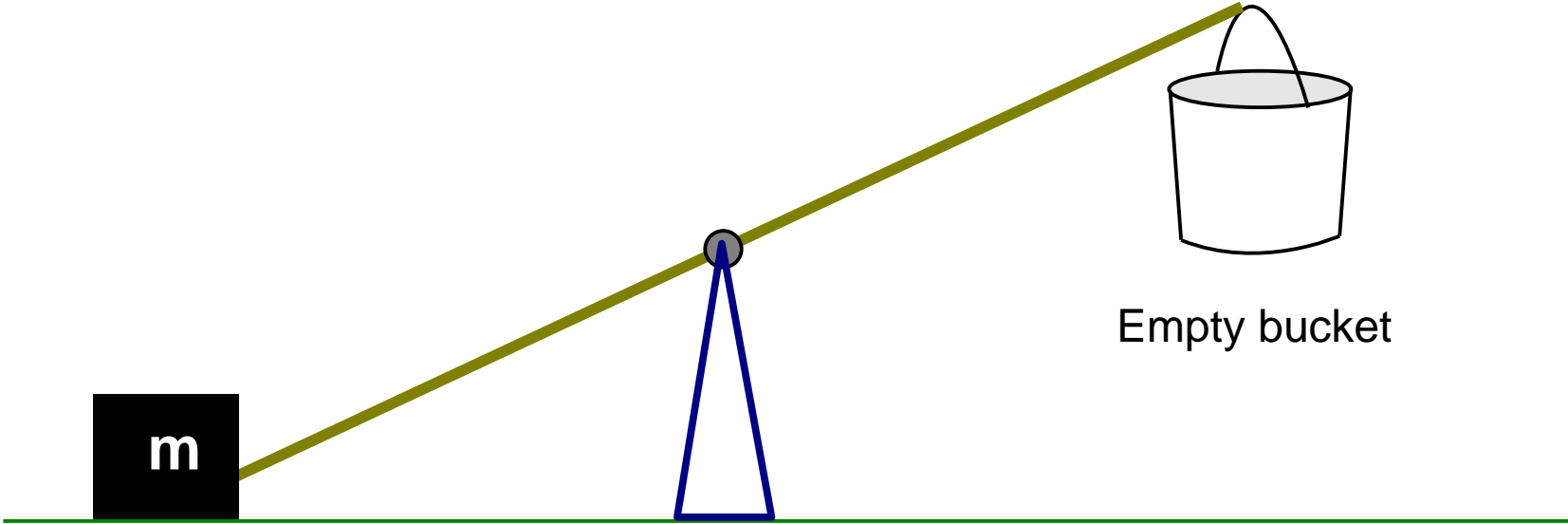
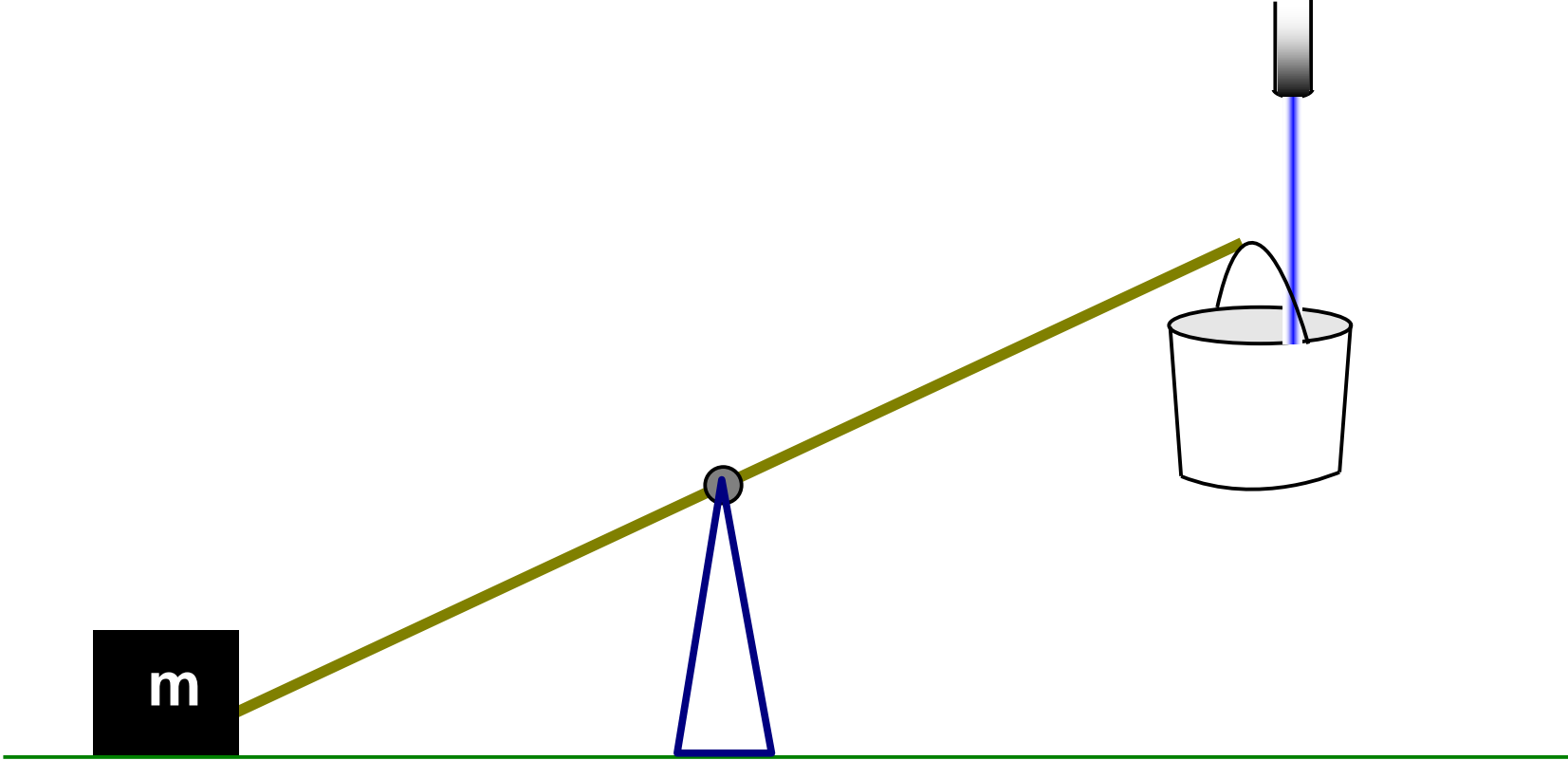
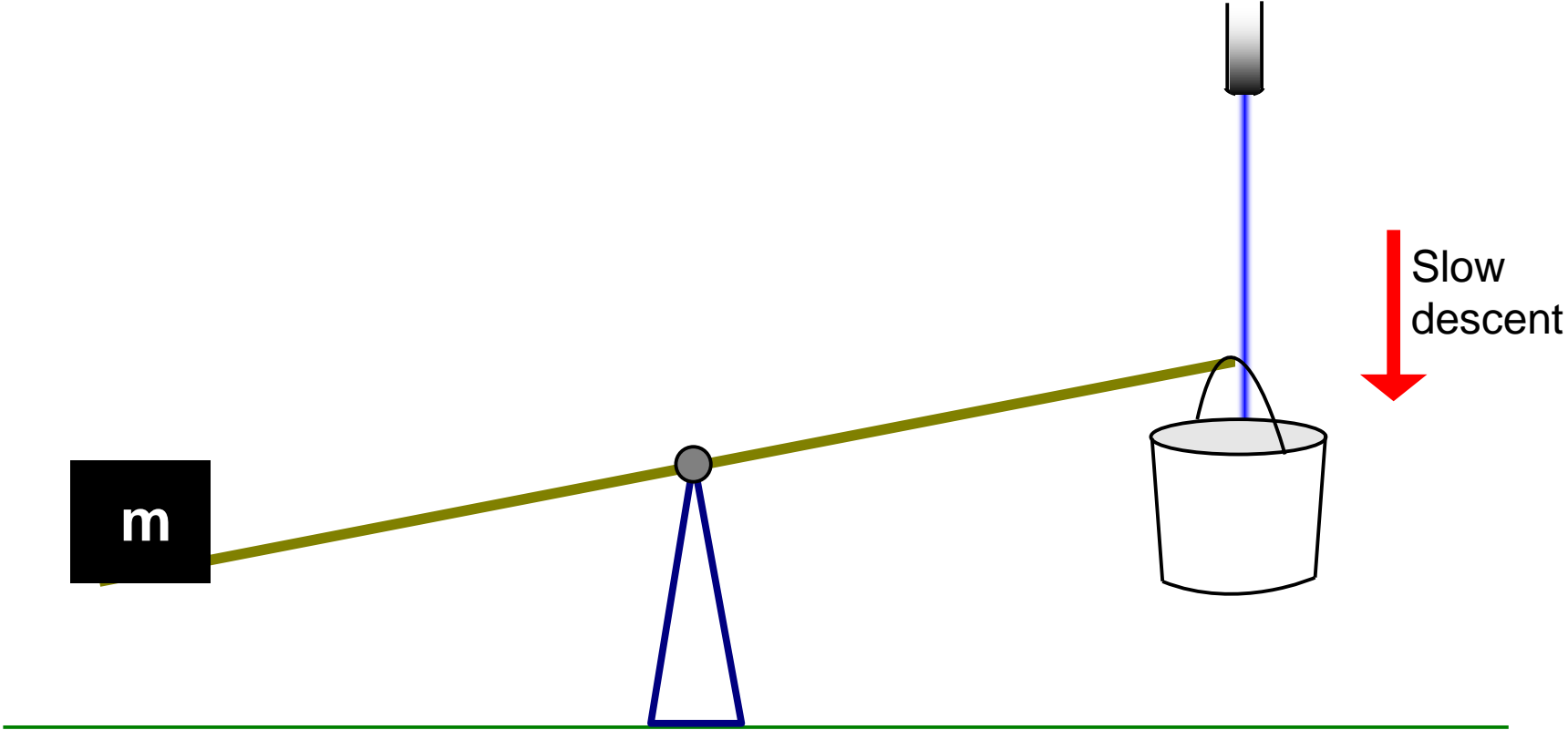
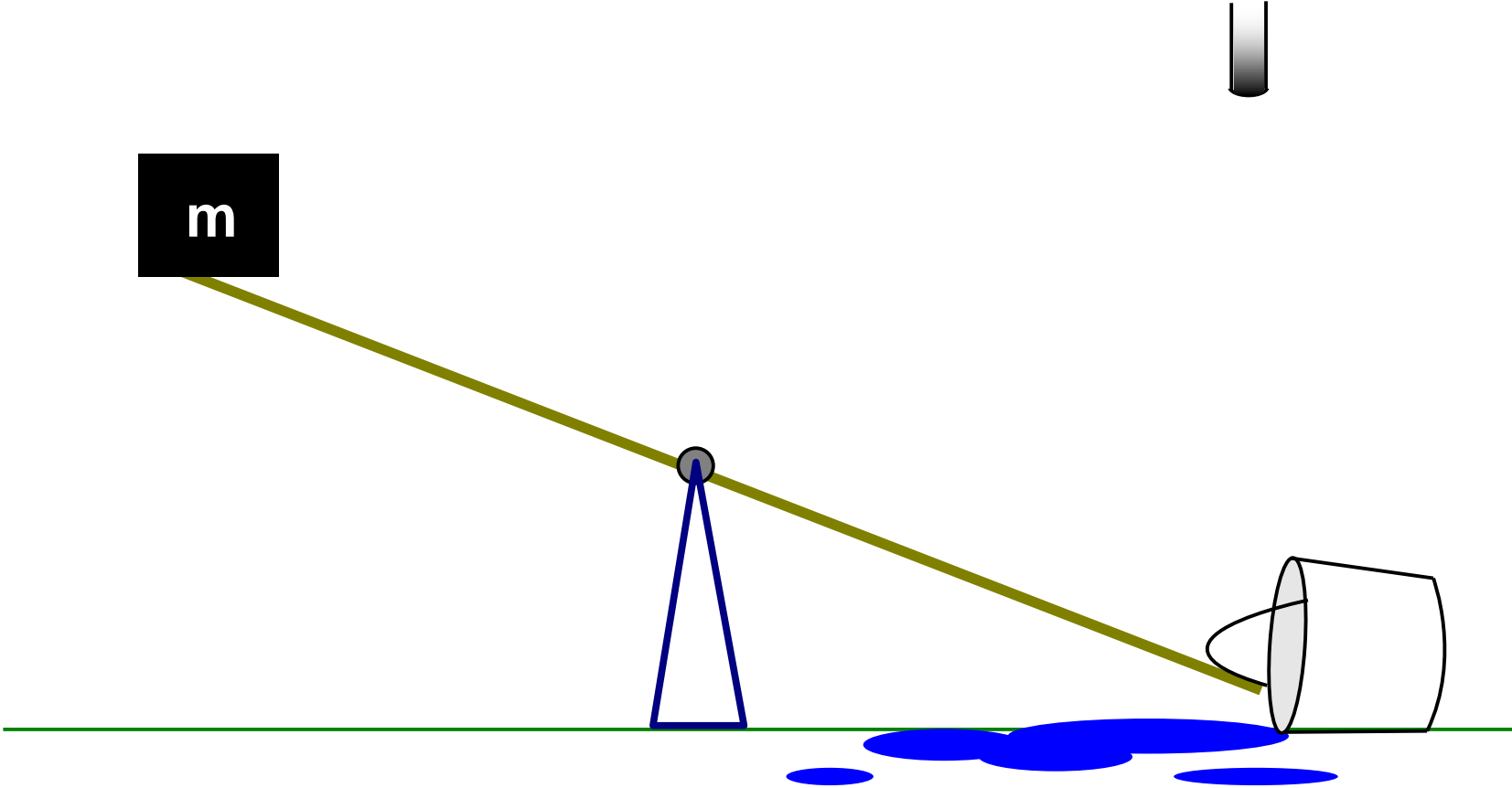


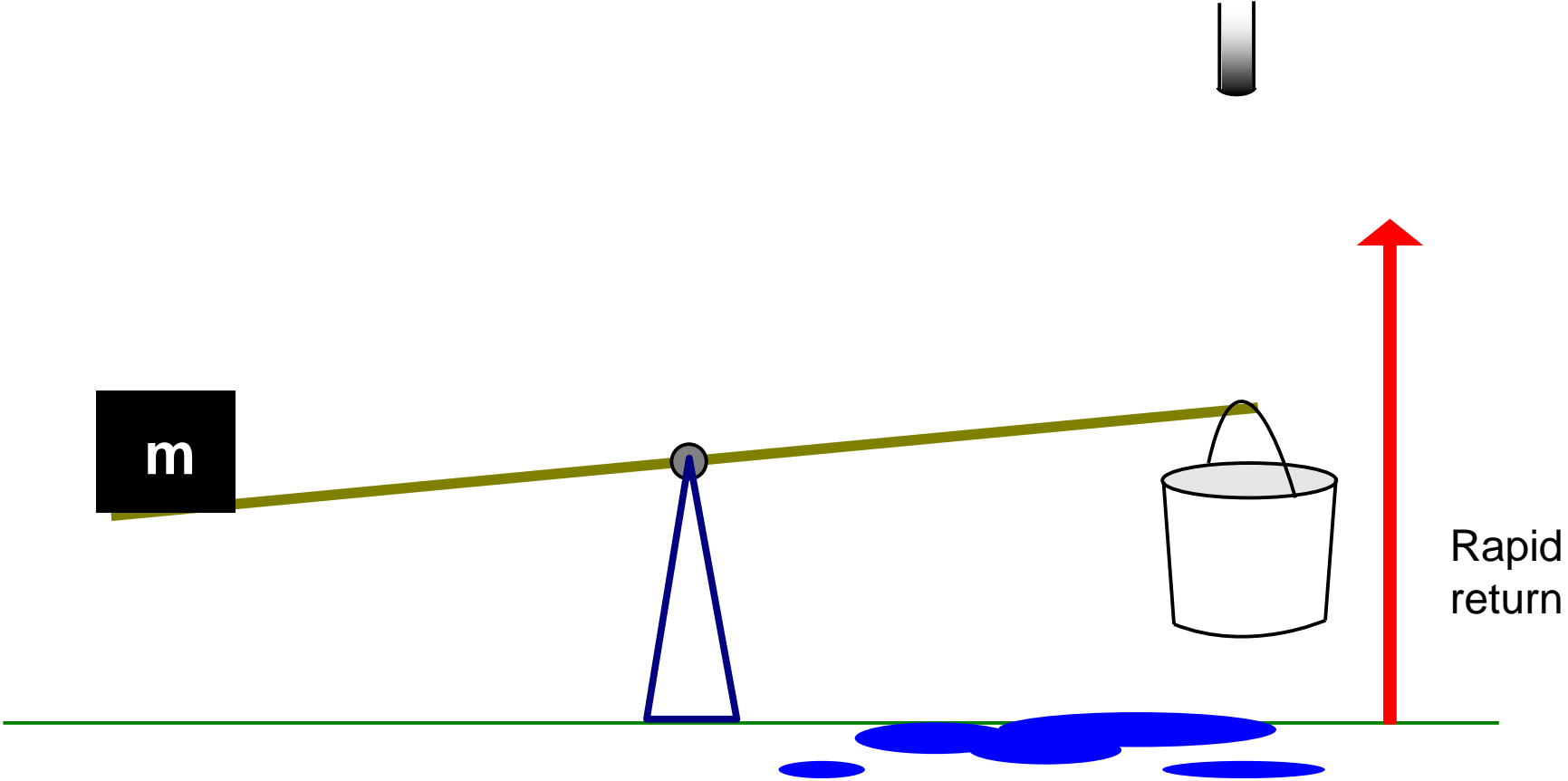
Lab 11: Relaxation oscillators

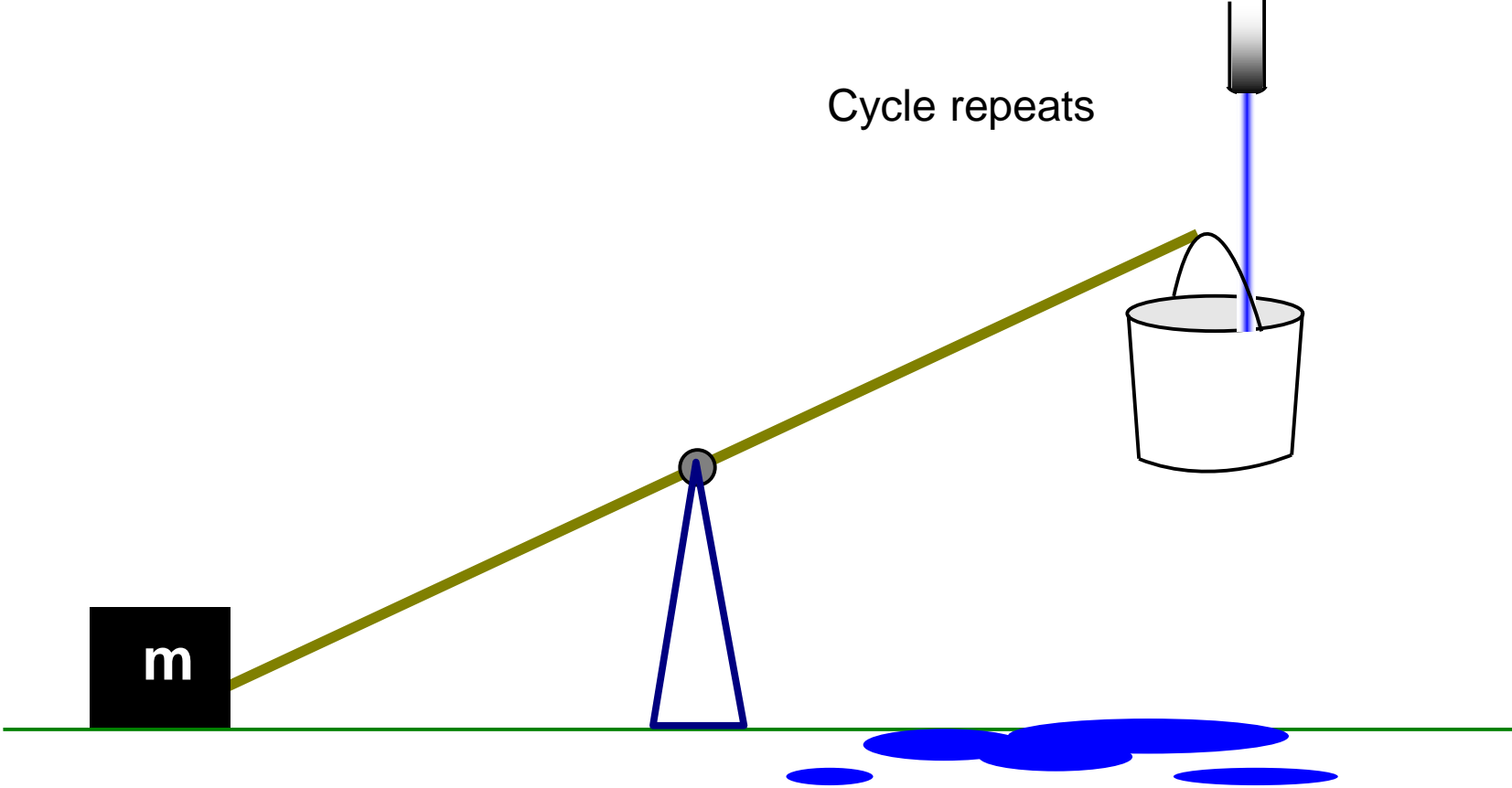












Relaxation oscillators:

Cycle of adding and dissipating energy

Asymmetric, non-sinusoidal time behavior

Examples of systems with this behavior:

- Laser physics
- Heart muscle
- Vocal cords
- Predator-prey population cycles

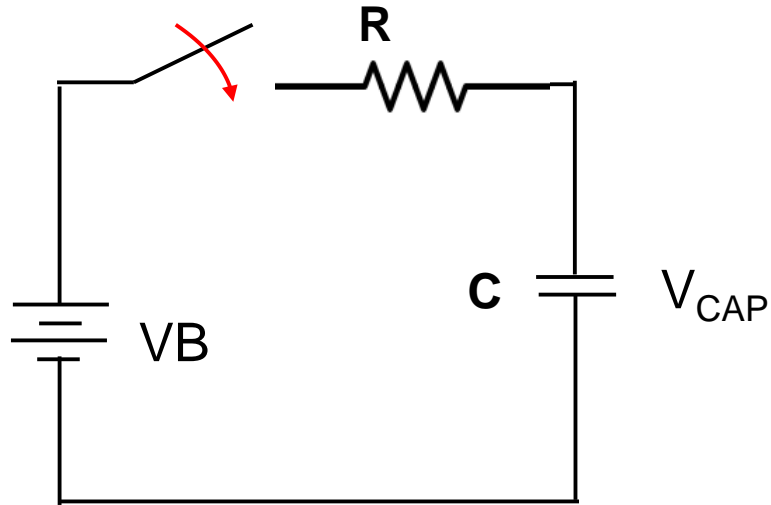


B. van der Pol
(1889-1959)

Feedback Mechanism

- **Energy Storage Device**
(capacitor, material system, gain medium for lasers, ...)
- **Rapid Switching device that releases the stored energy**
(diode, switch, discharge lamp, opamp, etc...)

Storing and releasing energy with a capacitor

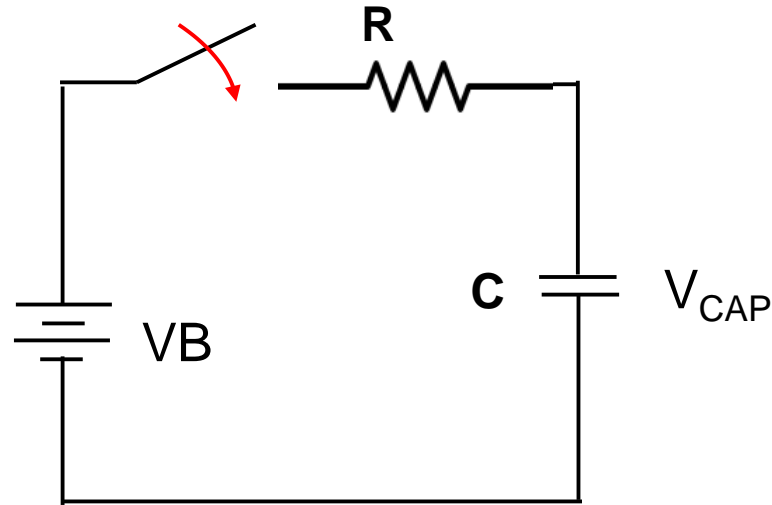


$$C = \frac{Q_{CAP}}{V_{CAP}}$$

Determine charging rate

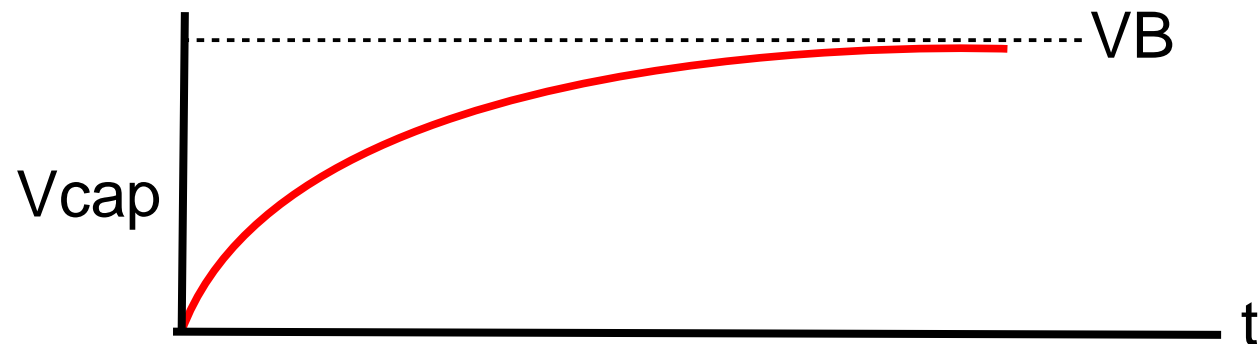
Don't use impedance $Z = 1/j\omega C$

Storing and releasing energy with a capacitor

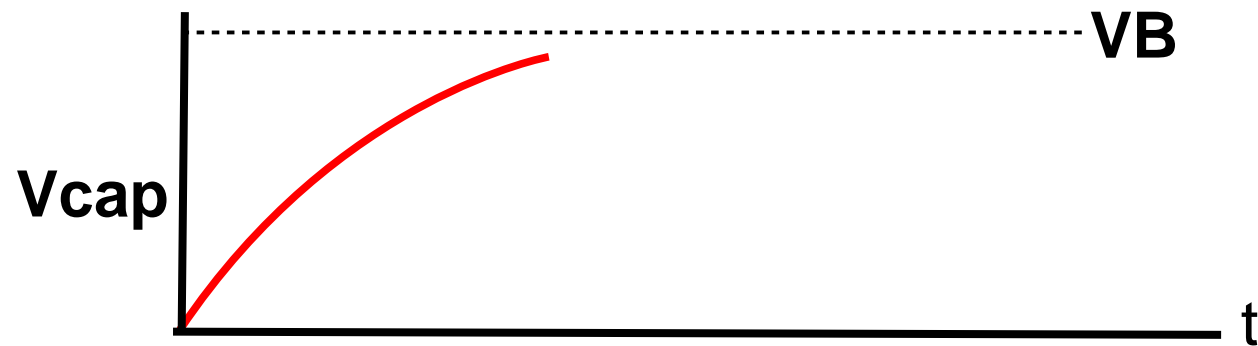
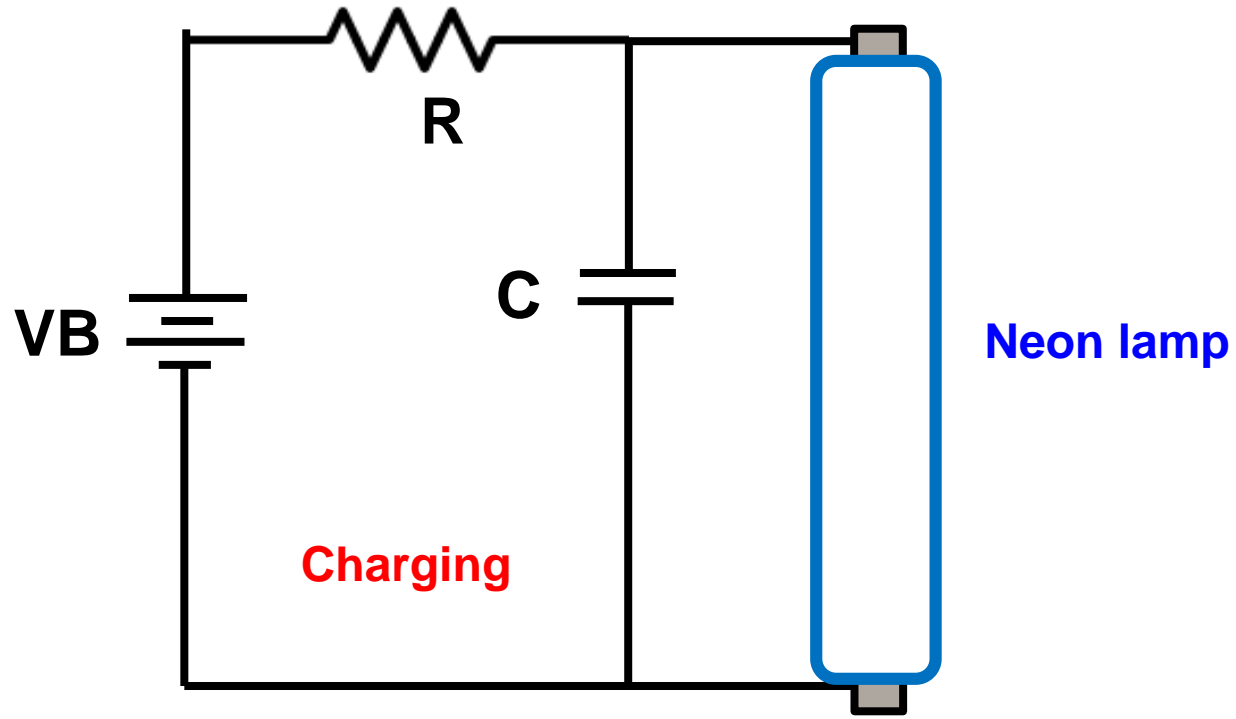


$$C = \frac{Q_{CAP}}{V_{CAP}}$$

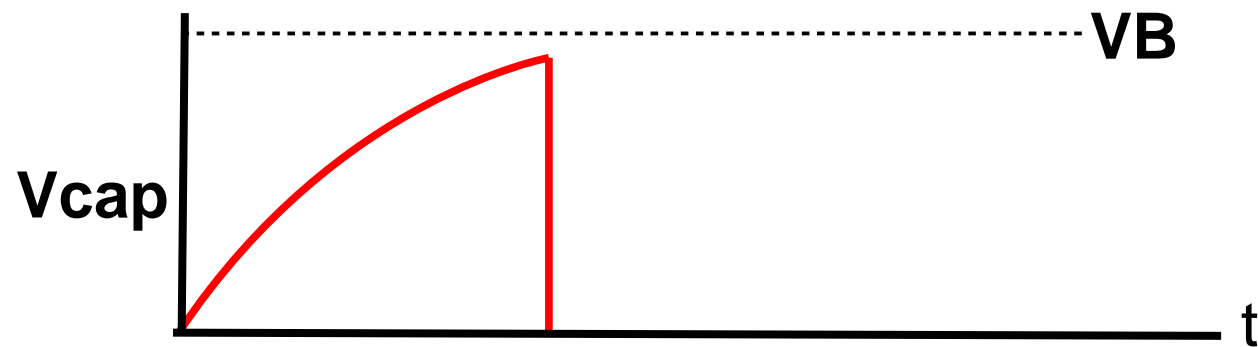
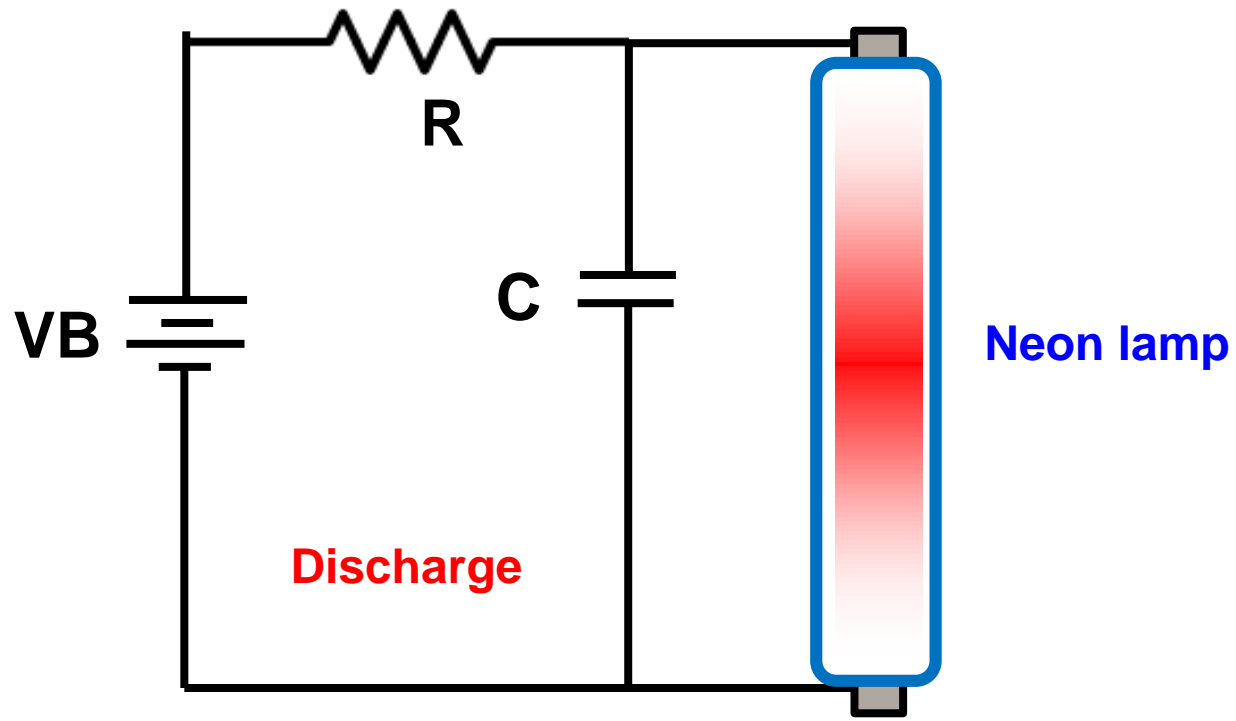
$$V_{cap} = V_B \left(1 - e^{-t/RC}\right) = V_B \left(1 - e^{-t/\tau}\right)$$



Storing and releasing energy with a capacitor

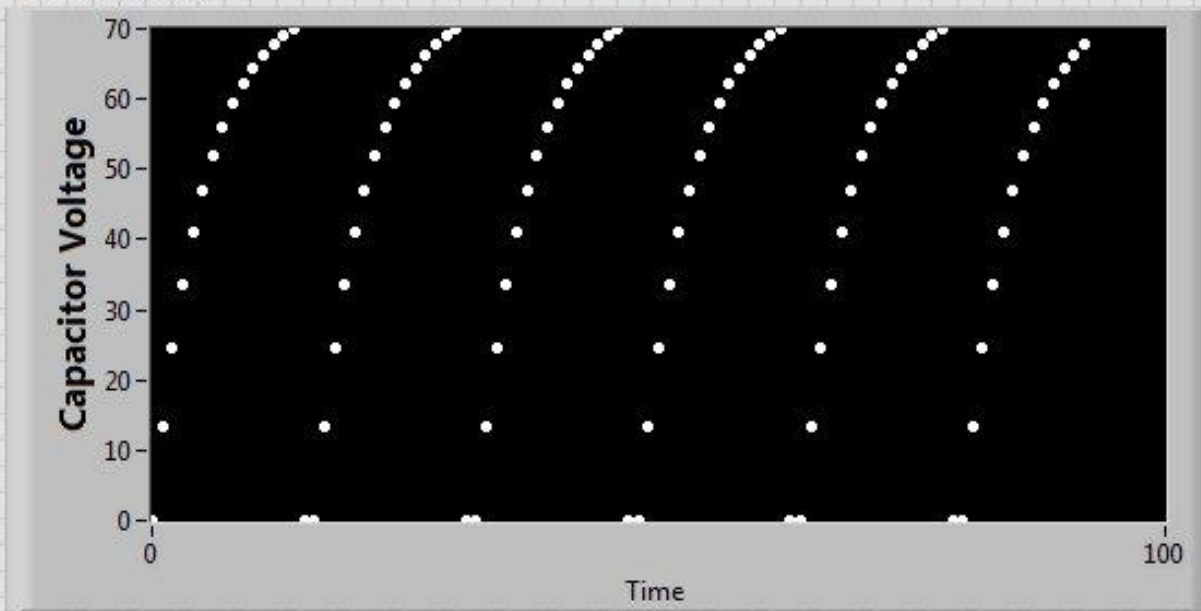


Storing and releasing energy with a capacitor

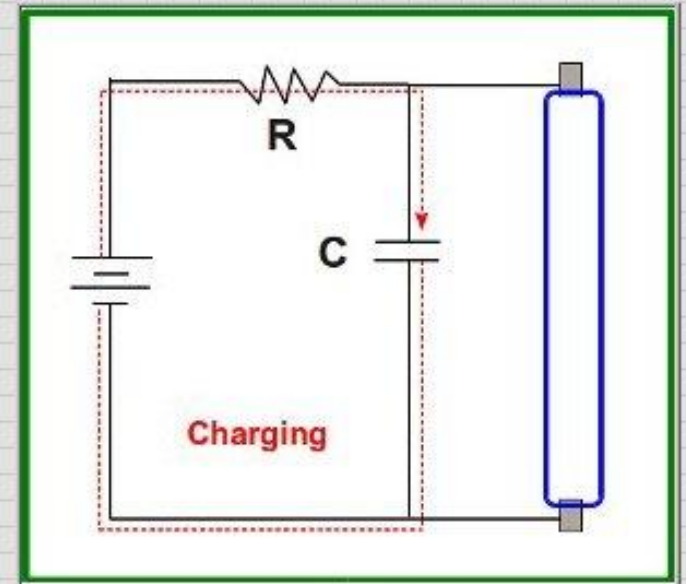


Neon Lamp Relaxation Oscillator

Waveform Chart

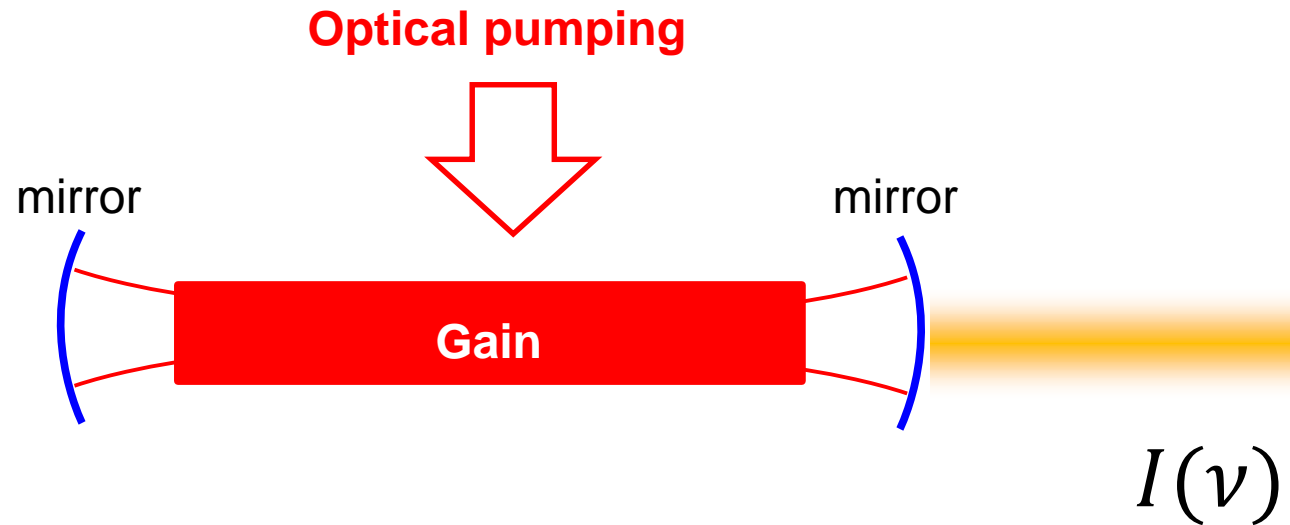


STOP



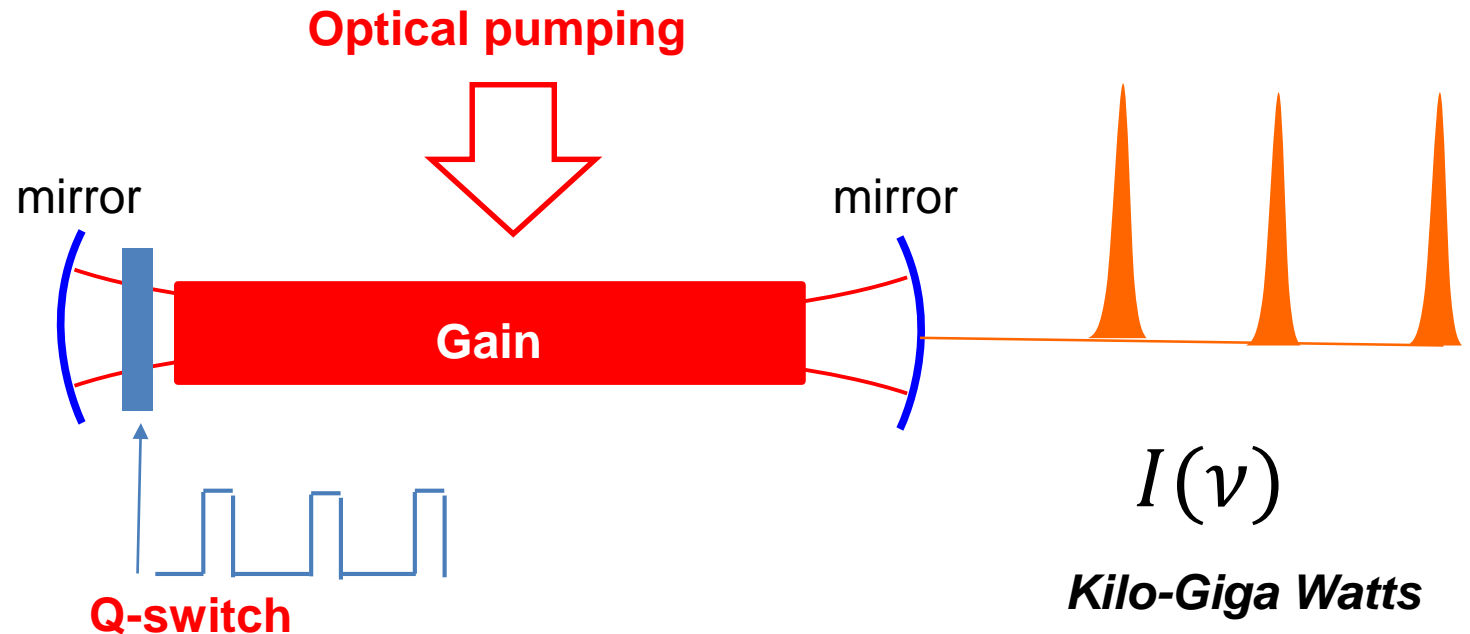
100- ↑ **DC voltage** R $1E+6$ C $1E-6$
75- **74.5** Time constant (sec)
50- dt
25- ↓
0- ↓

Laser Oscillators: Optical gain inside a feedback cavity



- *Excitation & Amplification*
- *Feedback*
 ➔ *Oscillation*

Laser Oscillators: Optical gain inside a feedback cavity



Q-switch

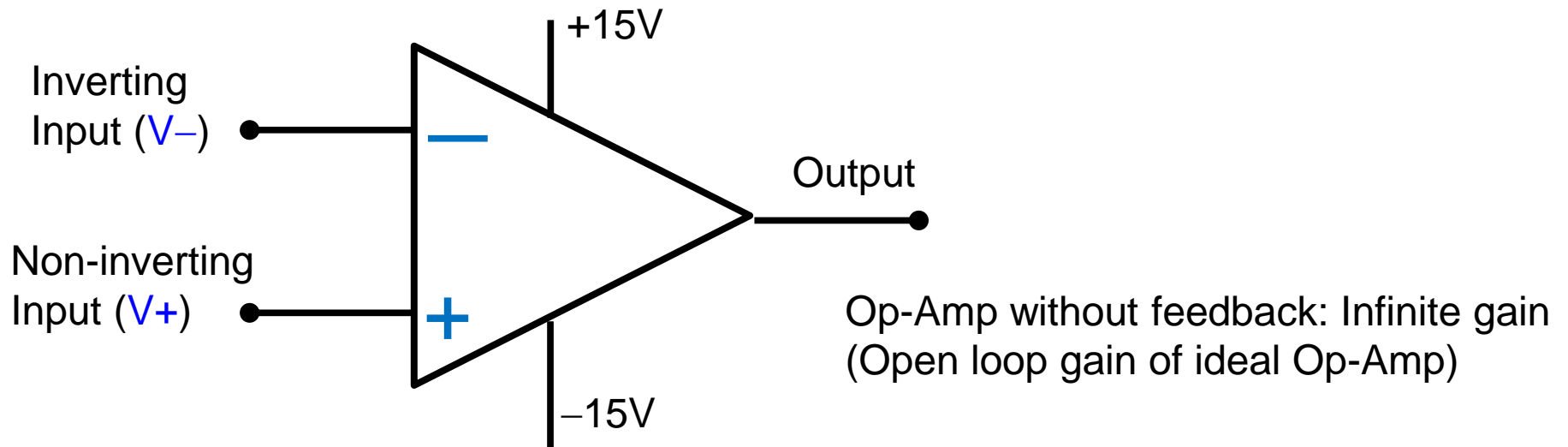
Control amount of feedback

Allows for build up of stored energy in Gain medium

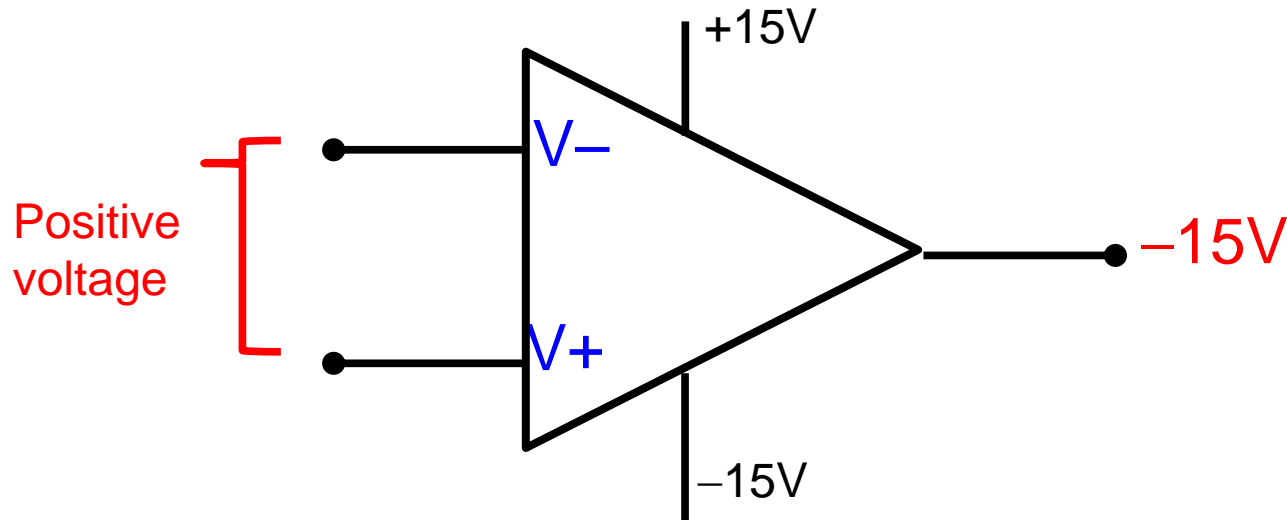
When switch is "opened", the stored energy is released

Gain medium stores energy: analogous to Capacitor

Relaxation oscillator: Implementation with Op-Amp



Relaxation oscillator: Implementation with Op-Amp

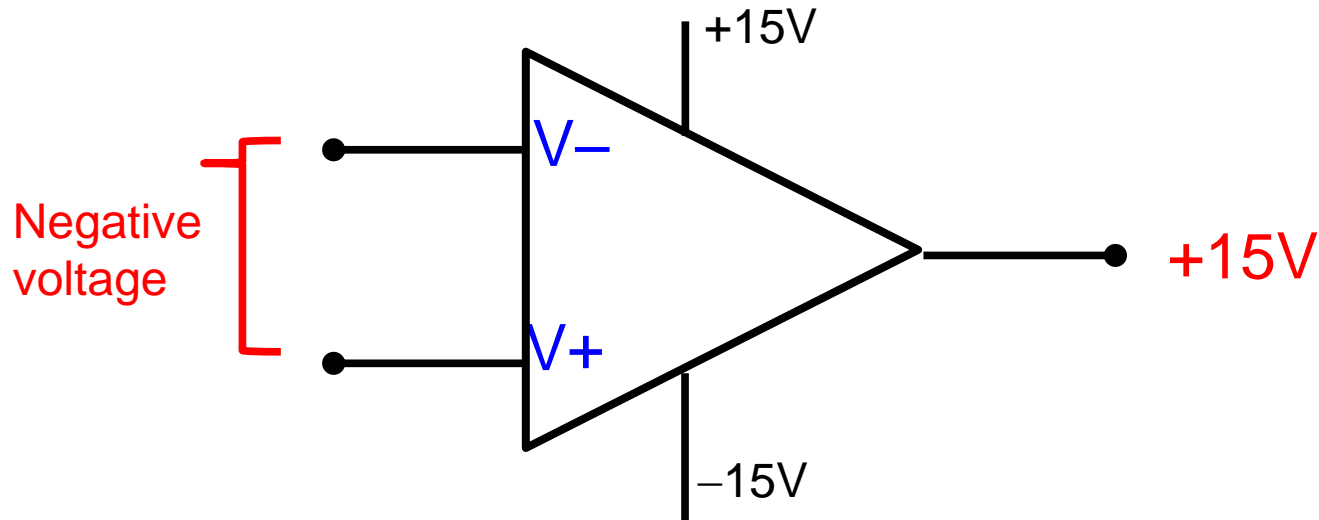


V_- greater than V_+

Output drives to negative ∞

Clamped at $-15V$ of power supply

Relaxation oscillator: Implementation with Op-Amp

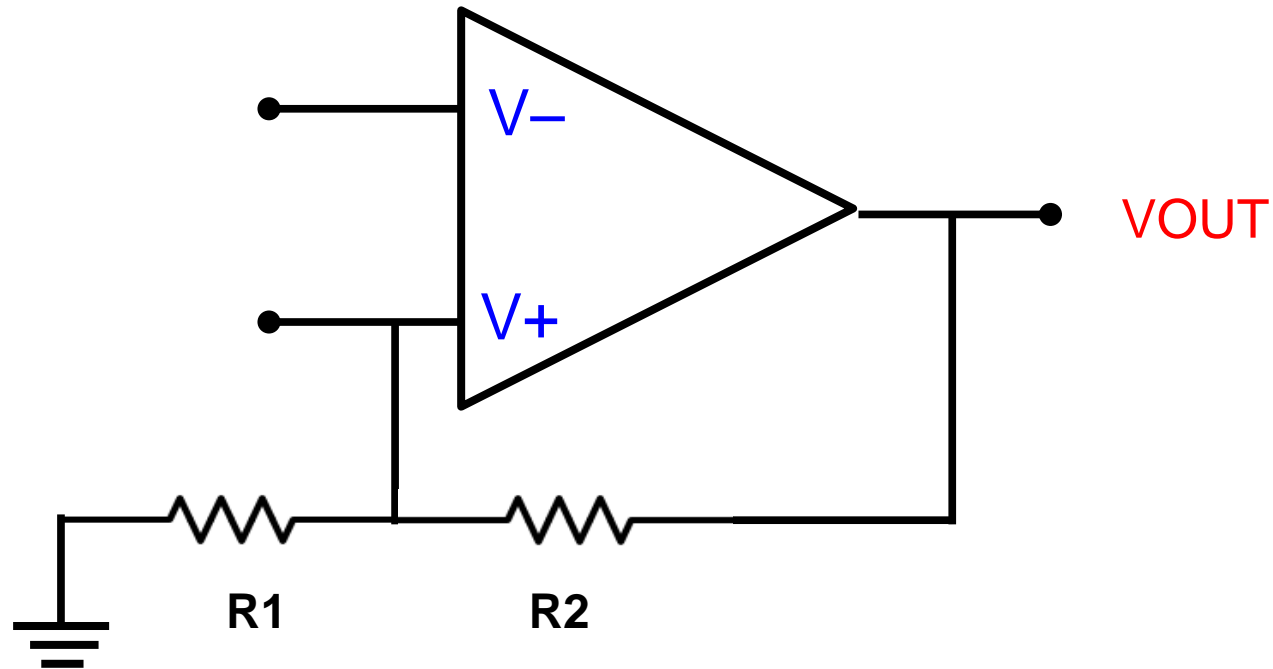


V_+ greater than V_-

Output drives to positive ∞

Clamped at $+15V$ of power supply

Relaxation oscillator: Implementation with Op-Amp

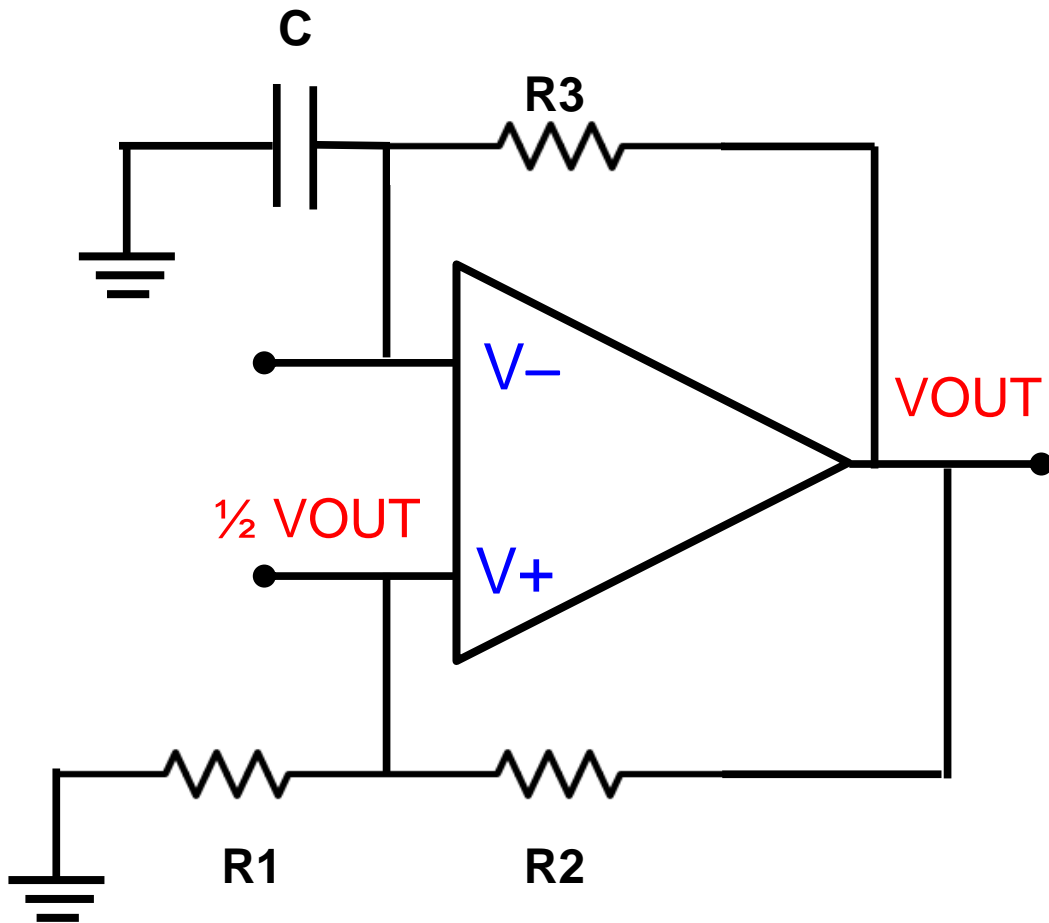


Make V_+ a reference voltage

Voltage divider: $R_1 = R_2$

$V_+ = \frac{1}{2} V_{OUT} = +7.5V$ or $-7.5V$

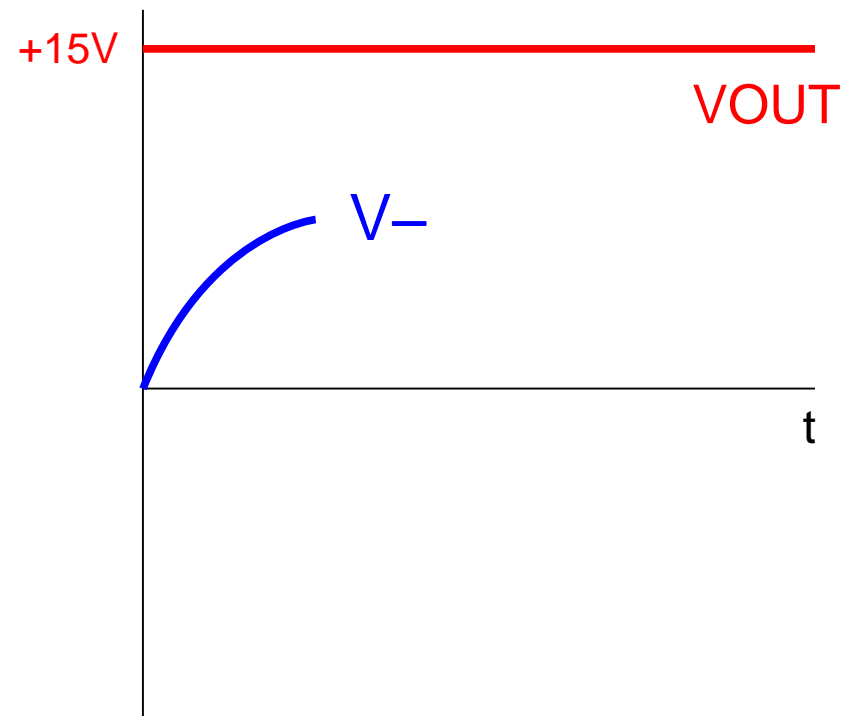
Relaxation oscillator: Implementation with Op-Amp



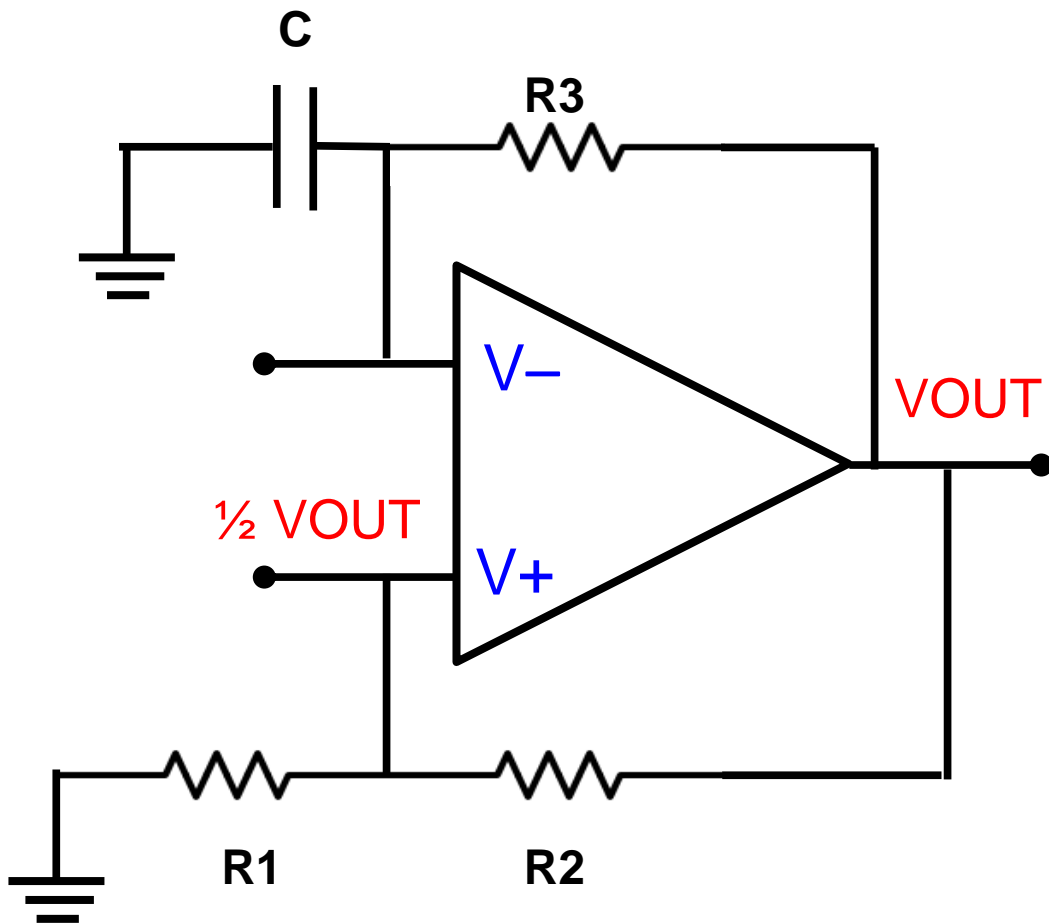
Add RC feedback to inverting input

V_- can't follow V_{OUT} instantly

Capacitor charges with $\tau = R_3 C$



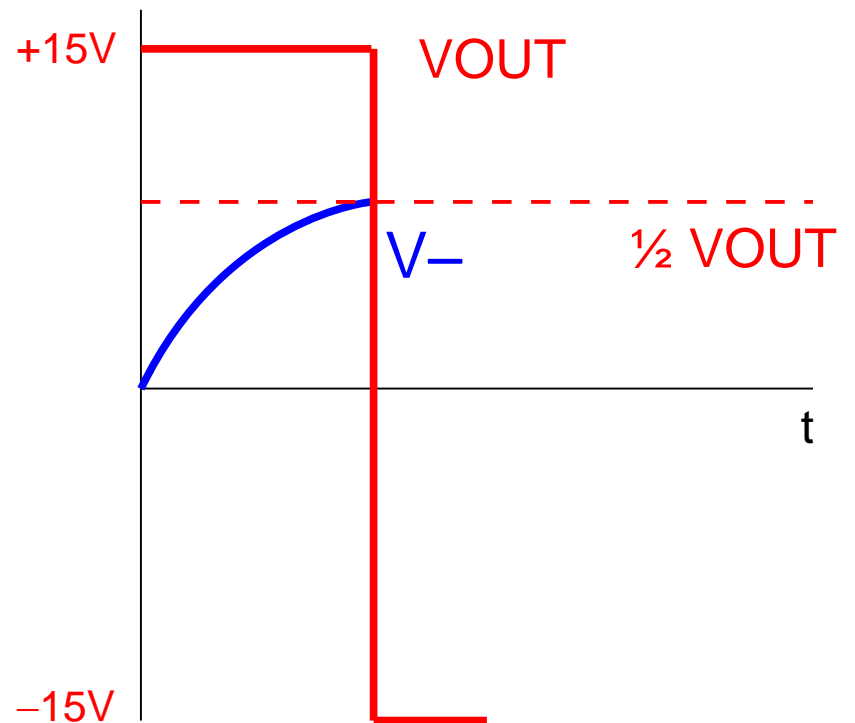
Relaxation oscillator: Implementation with Op-Amp



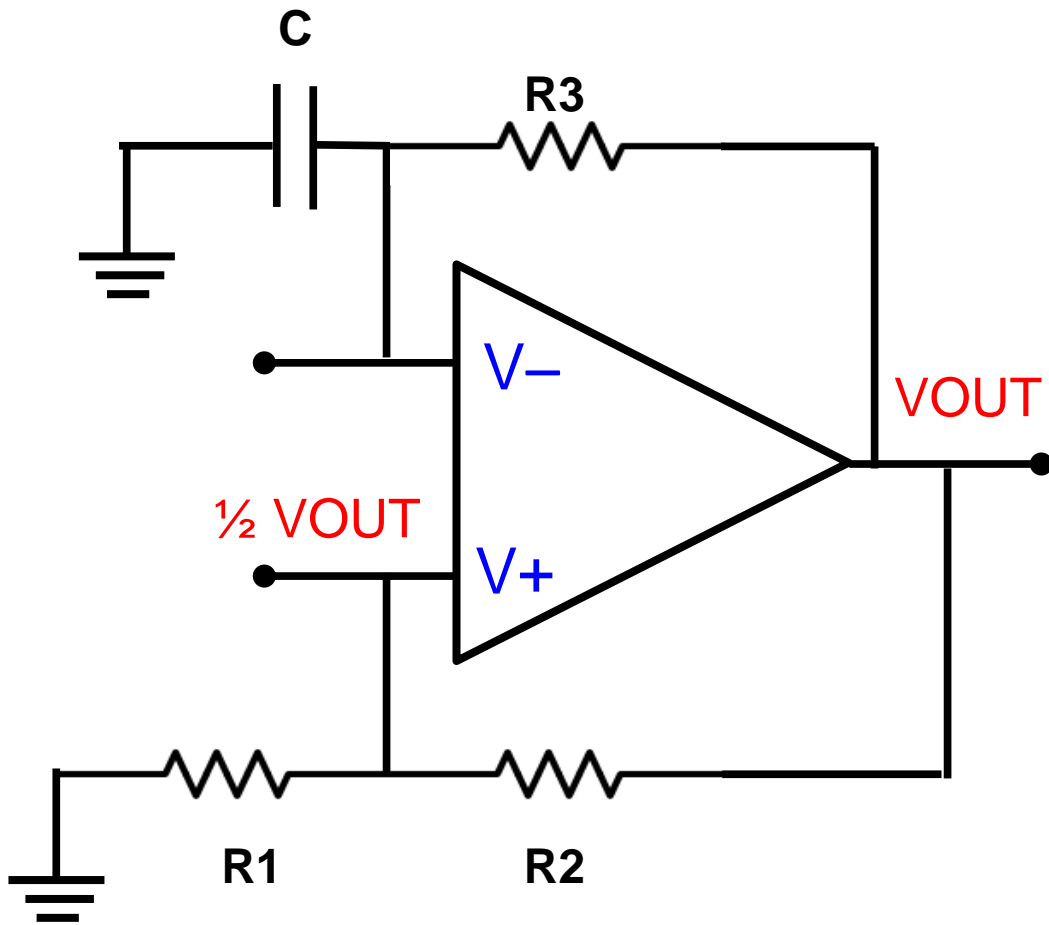
Add RC feedback to inverting input

V_- can't follow V_{OUT} instantly

Capacitor charges with $\tau = R_3 C$



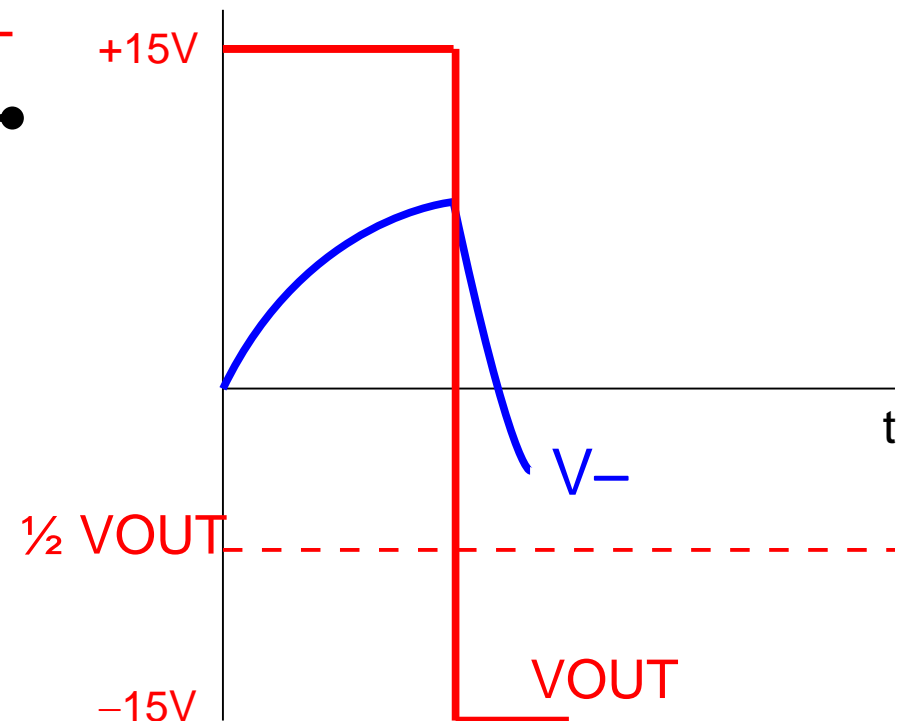
Relaxation oscillator: Implementation with Op-Amp



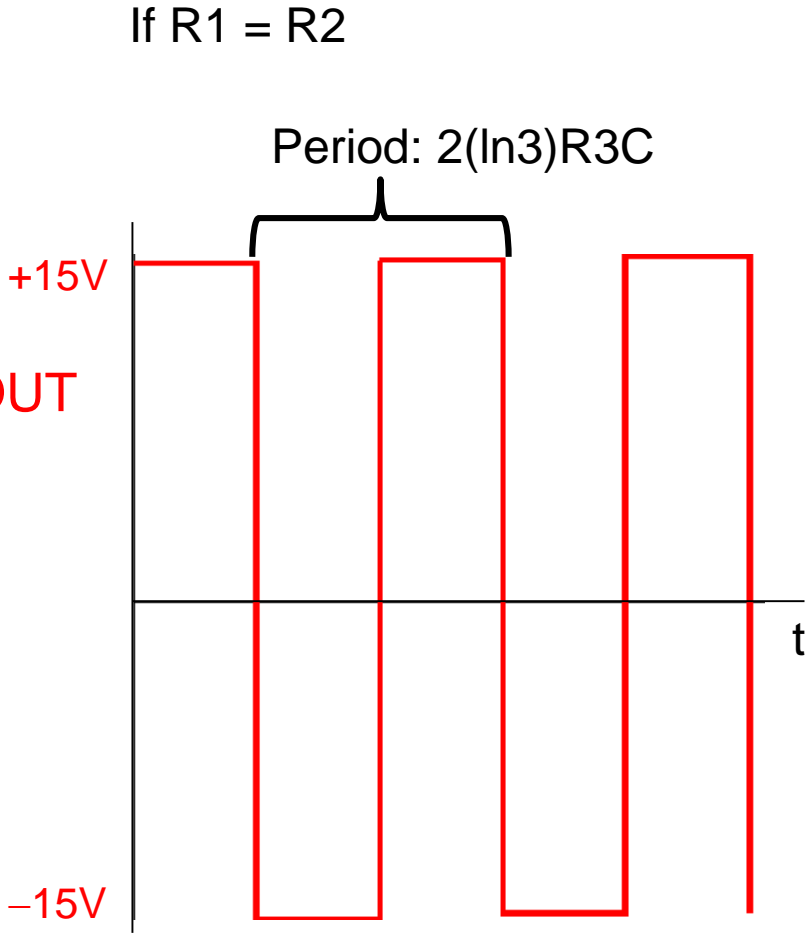
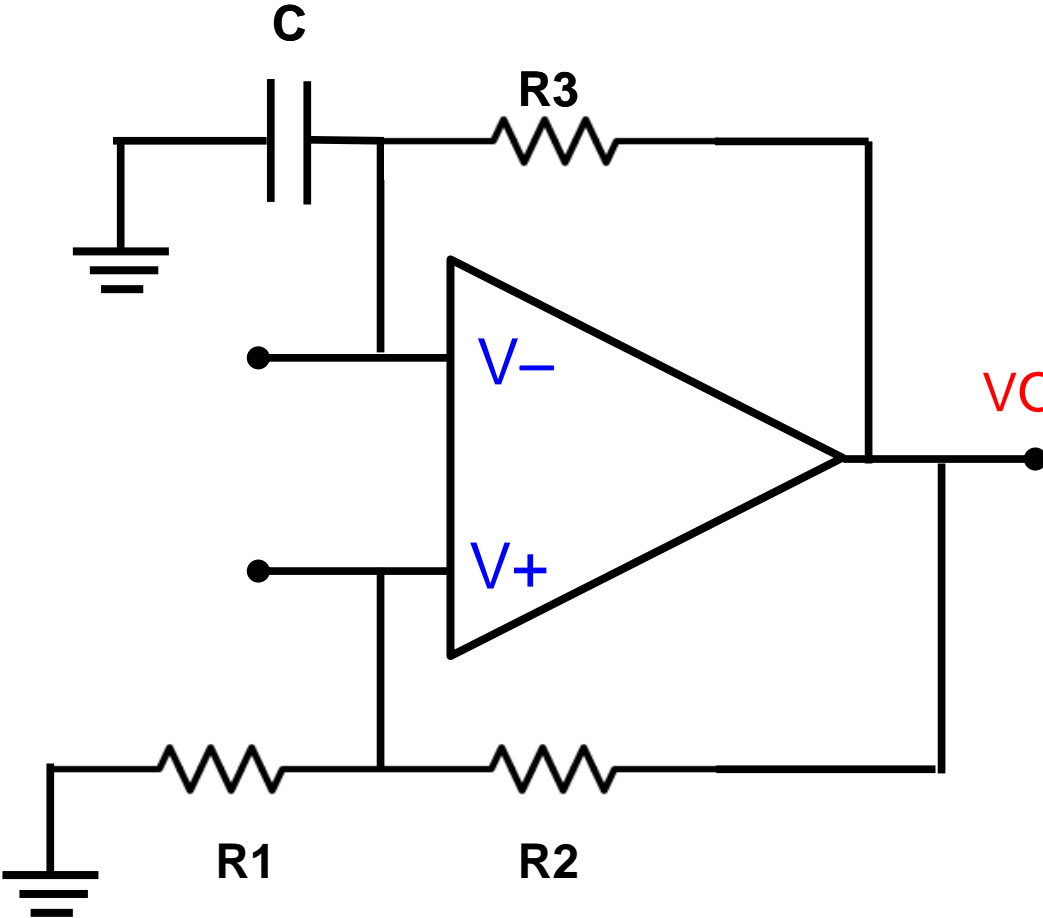
Add RC feedback to inverting input

V_- can't follow V_{OUT} instantly

Capacitor charges with $\tau = R_3 C$



Relaxation oscillator: Implementation with Op-Amp



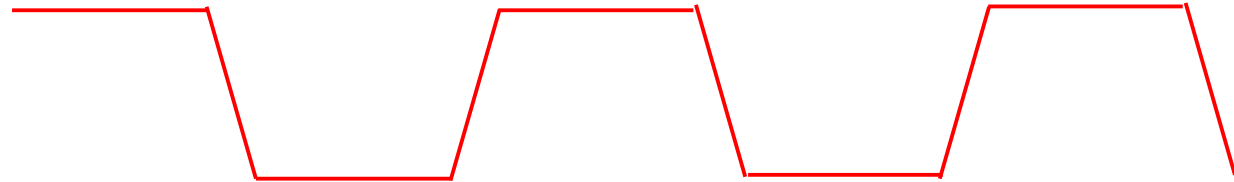
Slewing: Op-Amp cannot switch instantly

Limits the maximum oscillator frequency

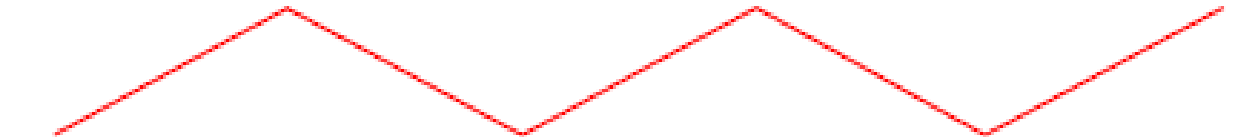
Ideal



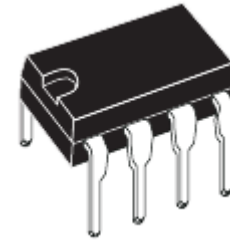
Slewing visible



Slewing severe



555 Timer Chip



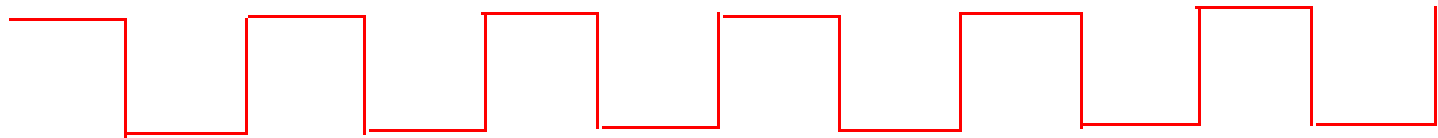
Make rectangular wave relaxation oscillator

Period adjustable with R and C

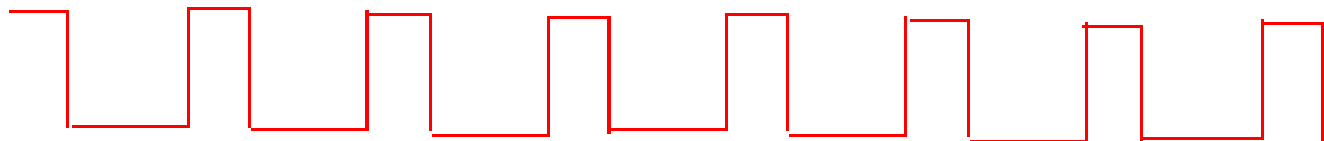
Set from microseconds to hours

Adjustable duty cycle: T_{ON} / Period

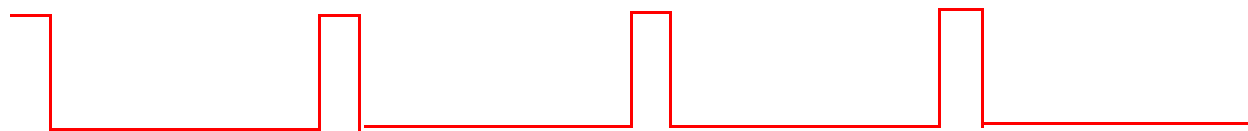
50% duty cycle



33% duty cycle



12.5% duty cycle



VI Server Architecture

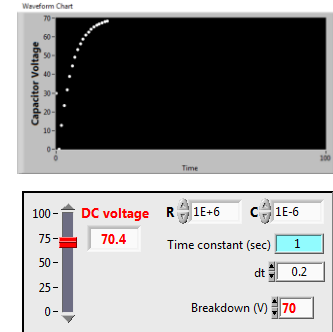
More tools...

How to....?

– Control objects in the Front Panel

Objects: Plots, Charts, Controls, indicators, etc...

– Edit properties of a running VI



Objects have **PROPERTIES** and **METHODS**

PROPERTIES are attributes of an object

- Color
- Size
- Position

METHODS are actions or operations of an object

- Initializing a control
- Save data to a spread sheet
- Sending data via Ethernet

PROPERTIES are changed with **PROPERTY NODES**

METHODS are changed with **INVOKE NODES**

More advanced, data processing, communication.. (left for later)

Storing and releasing energy with a capacitor: Capacitive discharge ignition

