



# **SNS COLLEGE OF TECHNOLOGY**

**Coimbatore-35**  
**An Autonomous Institution**



Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A++' Grade  
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

## **DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING**

### **19ECB204 – LINEAR AND DIGITAL CIRCUITS**

II YEAR/ III SEMESTER  
1

**UNIT 1 – FUNDAMENTALS OF OPAMP**

**TOPIC 5 – Integrator and Differentiator**



Guess?????

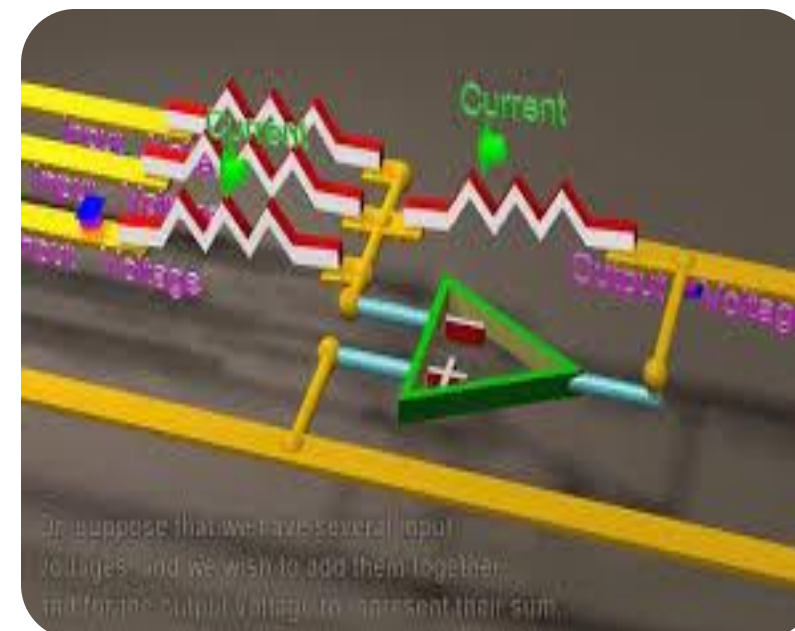




# Why?



- ❑ It is a type of electronic amplifier
- ❑ It amplifies the difference between two input voltages
- ❑ Important part of many engineering and scientific applications....

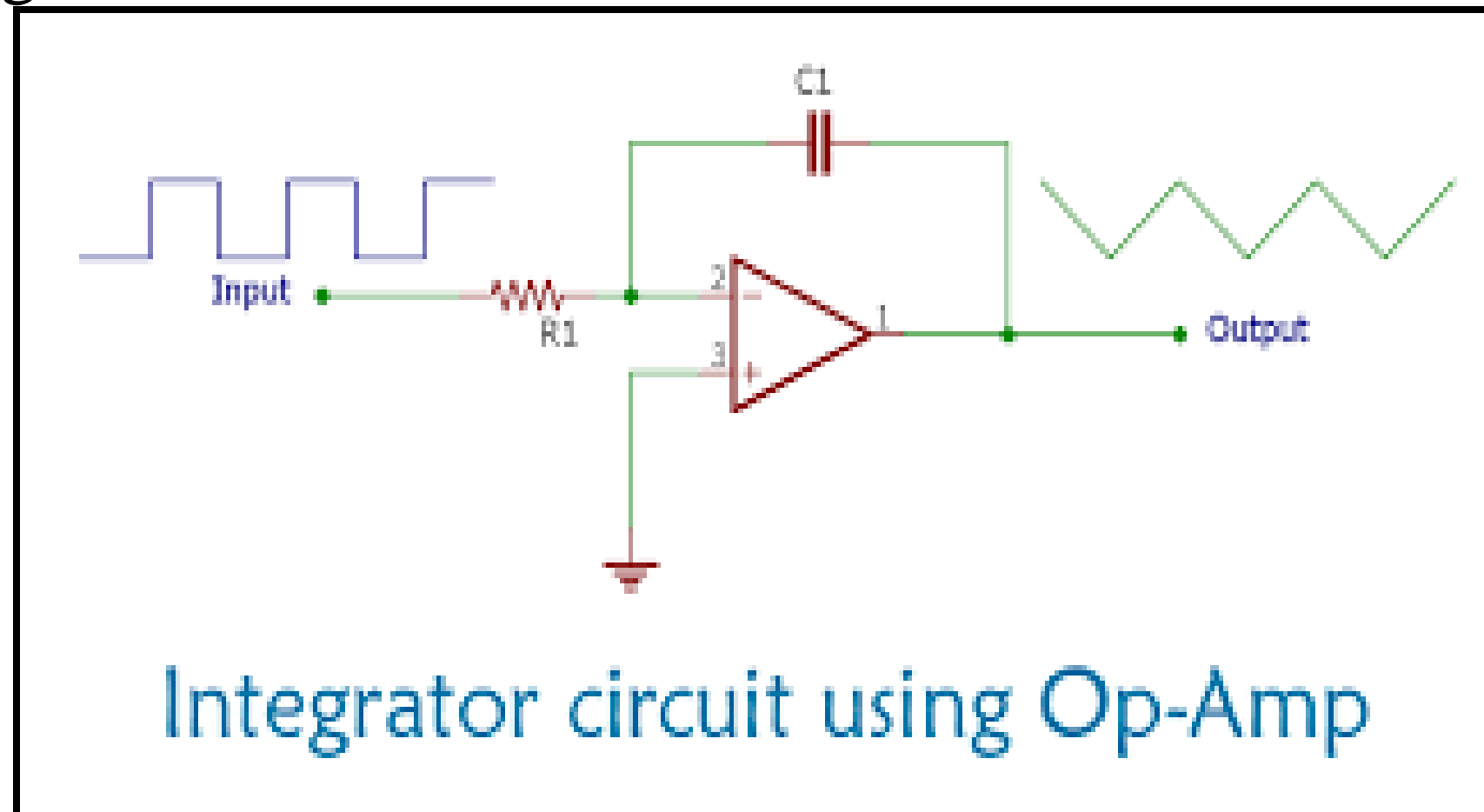




# Op-amp Integrator



- It's a operational amplifier circuit that performs the mathematical operation of integration
- It produces an output voltage which is proportional to the integral of the input voltage





# Op-Amp Integrator



From the above circuit,

**G** denoted as ground terminal

The flow of current through the ground terminal is equivalent to the flow of current out,

we can write as;

$$\text{if } \mathbf{I_{in} + I_f = 0}$$

$$\mathbf{I_{in} = -I_f}$$

$$\mathbf{V_{in} - V_a / R = -C \, d/dt(V_0 - V_a)}$$

$$\text{where } \mathbf{V_a = 0}$$

$$\mathbf{V_{in} / R = -C \, d/dt( v_0 )}$$

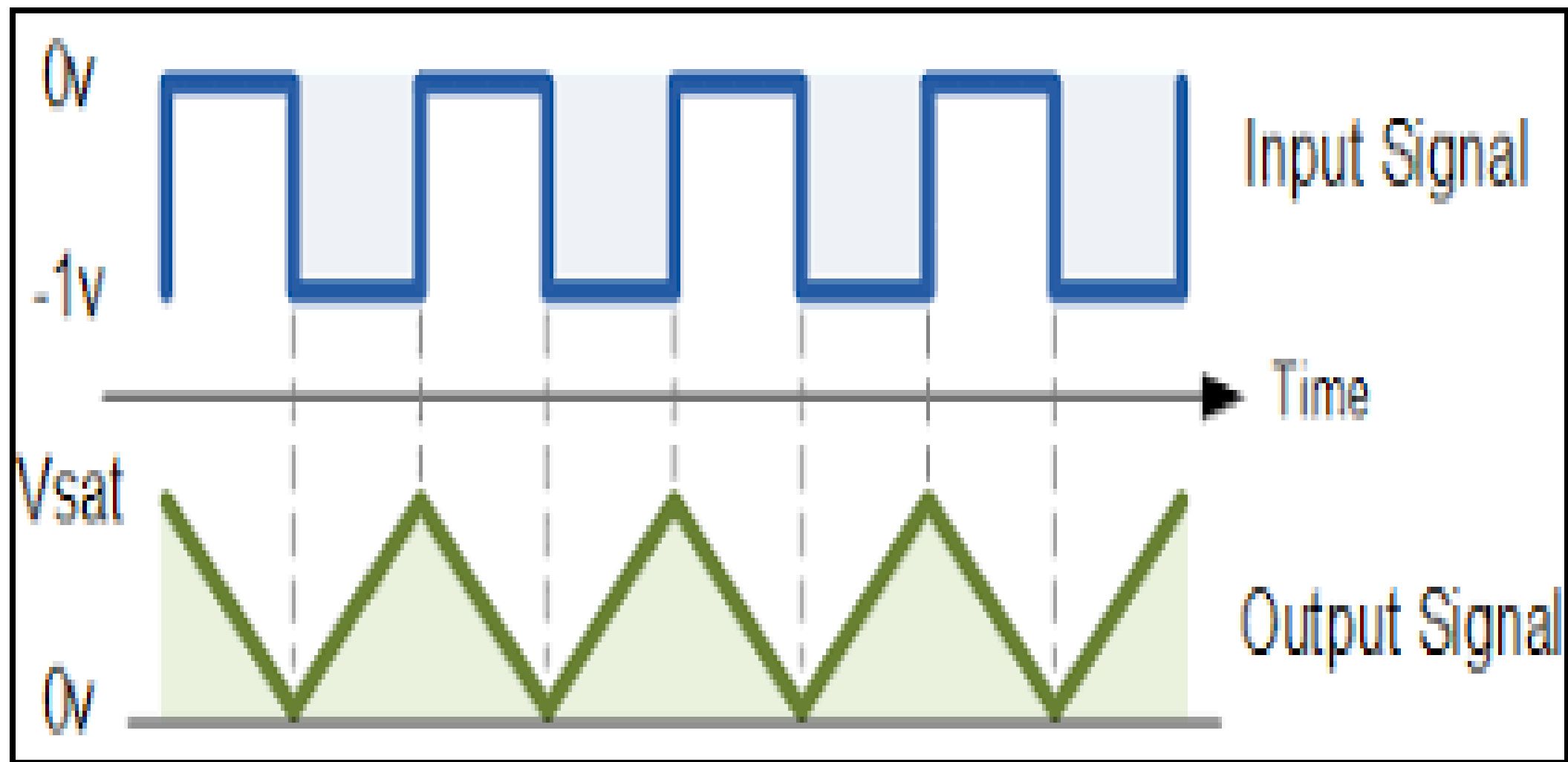
Integrate the above equation,

$$\mathbf{1/R \text{ (or) } V_{out} = -(V_{in}/R) C \, dt + c}$$

The  $V_{out}$  voltage is equal to the constant  $-1/RC$  and integral of input voltage  $V_{in}$ .

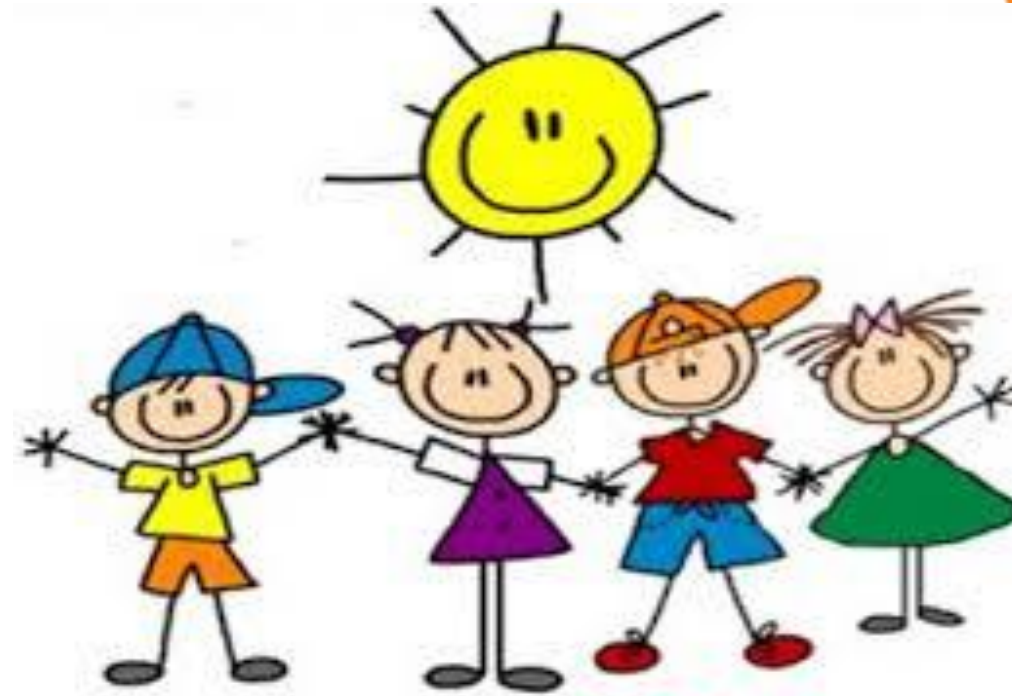


# Op-Amp Integrator waveform





# Activity



## *In class activity*

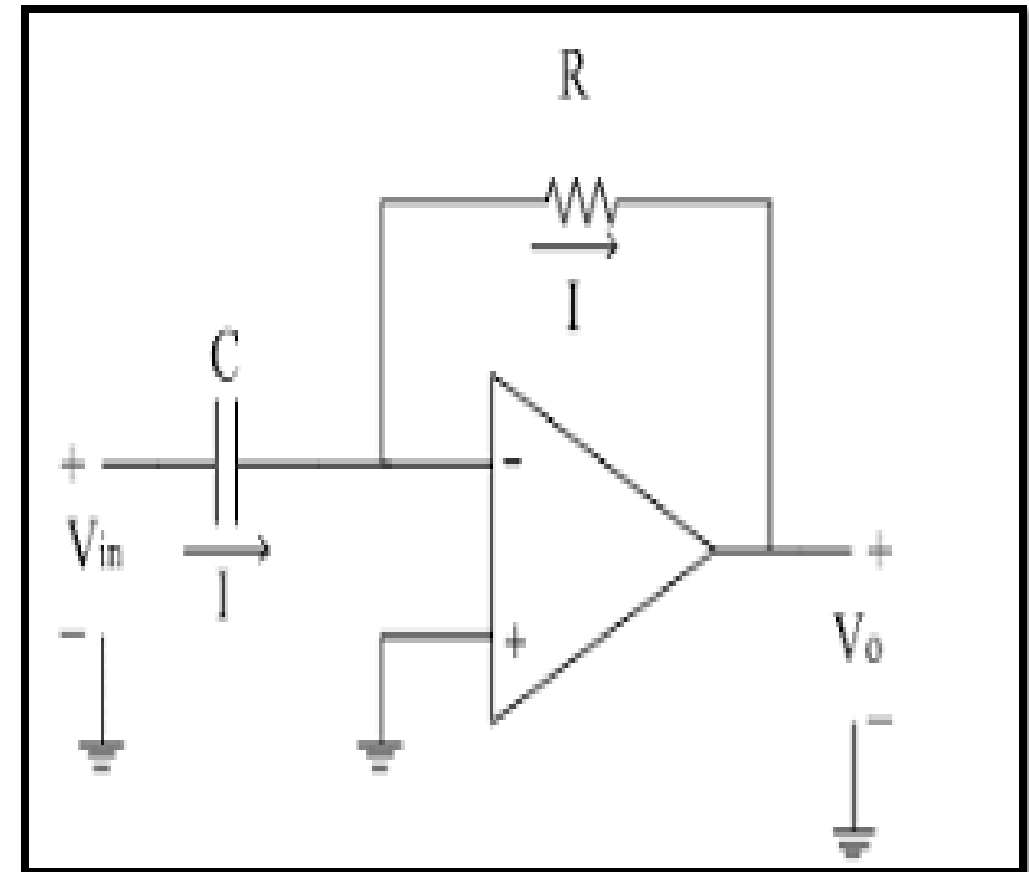
Students should make the correct shape from the given tangram kit.



# Op-amp Differentiator



- ❑ A differentiator circuit is one in which the voltage output is directly proportional to the rate of change of the input voltage with respect to time
- ❑ This means that a fast change to the input voltage signal, the greater the output voltage changes in response







# Output Stage



- The op-amp node voltage at inverting terminal is zero
- The flow of current through the capacitor can be written as

$$I_{in} = I_f$$

$$\text{Where } I_f = - V_{out} / R_f$$

The capacitor charge equals the voltage with capacitance times across the capacitor

$$Q = C * V_{in}$$



# Output Stage



Charge rate change

$$dq/dt = C d/dt(V_{in})$$

$$I_{in} = C d/dt(V_{in}) = I_f$$

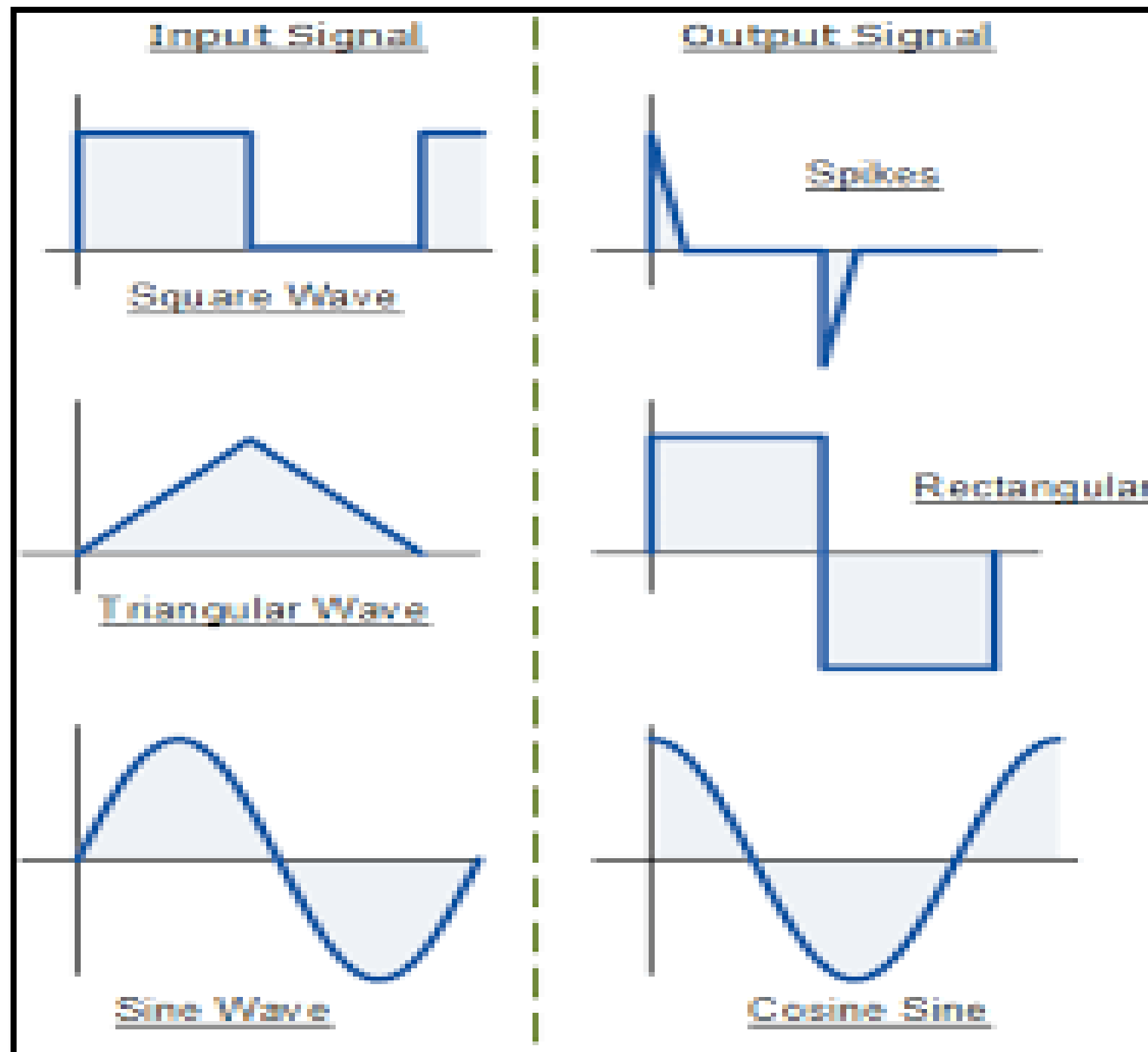
$$-V_{out}/R_f = C d/dt(V_{in})$$

An ideal output voltage ( $V_{out}$ ) for the operational amplifier differentiator is

$$V_{out} = - R_f C d/dt(V_{in})$$



# Differentiator waveform





# Applications



- ❑ Differentiating amplifier are most commonly designed to operate a triangular and rectangular signals
- ❑ Differentiators also find application as wave shaping circuits to detect high frequency components in the input signal
- ❑ Integrator circuits are mostly used in Analog computers, Analog to Digital Converters and wave shaping Circuits



# Assessment



- 1. Write down the condition for good differentiation .**
- 2. What are the limitations of the basic differentiator circuit?**





**THANK YOU**