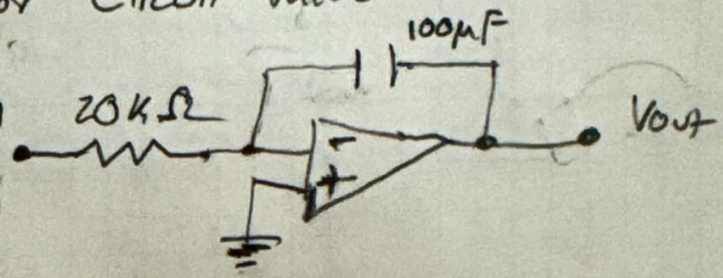
Integrator Circuit value



Time Constant τ

$$\tau = RC = (20000\ \Omega)(100 \cdot 10^{-6}\ F) = 2s$$

Looking at the graphs, the period of each wave is 2s.

$$T = 2s$$

Therefore $f = \frac{1}{T} = 0.5\ Hz$

$$\omega = 2\pi f = \pi \frac{rad}{s}$$

For the equation for an integrator is

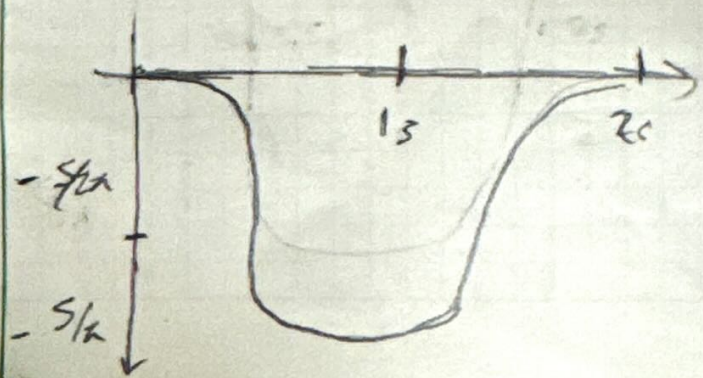
$$V_{out} = -\frac{1}{RC}\int_0^+ V_{in}\,dt$$

for the sine wave. The input waveform is given by $V_{in} = 5\sin(\omega t)$

Therefore

$$V_{out} = -\frac{1}{2}\left[-\frac{5}{\omega}\cos(\omega t)\right]_0^+ = \frac{5}{2\pi}\left(\cos(\pi t) + 1\right)$$

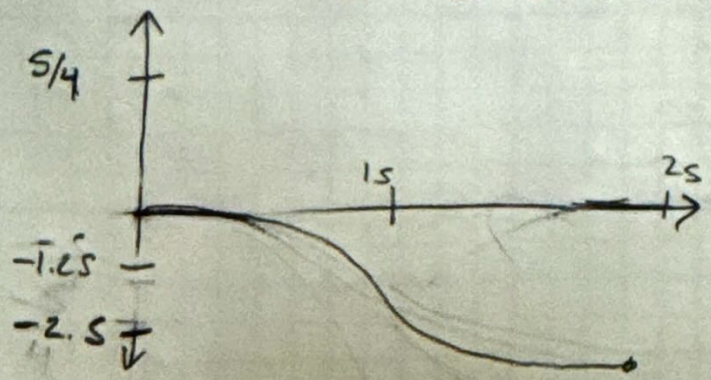
The output wave form would look like mathematically



For the triangle wave, the upward part of the wave is given by $V_{in} = 5t$, and the downward slope is given by $V_{in} = 10 - 5t$

therefore $V_{down} = -\frac{1}{2}\left[10t - \frac{5t^2}{2}\right]_1^+ = \frac{5t^2}{4} - 5t + \frac{5}{2}$

$$V_{up} = -\frac{1}{2}\left[\frac{5t}{2}\right]_0^+ = -\frac{5t^2}{4}$$



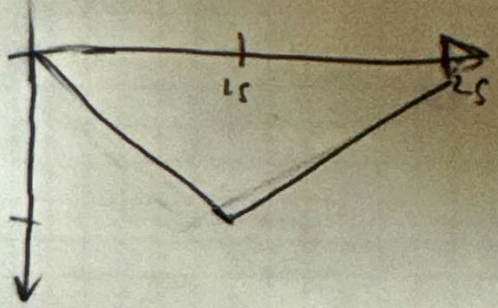
For the square wave

The input voltage is a constant +10V for $0 < t < 1$ and a constant -10V for $1 < t < 2$

for $0 < t < 1$ $V_{out} = -5t$

for $1 < t < 2$ $V_{out} = 5t - 5$

Output waveform



In lab the mean voltages were always ≈ 0. The reason for this is because the capacitor has some leakage current that ge. causes the capacitor to slowly discharge and move the mean to to about 0V. In time as this leakage current continues to effect the capacitor.

For the differentiator

τ is the same (2s)
T is the same (2s)
w is the same (π)

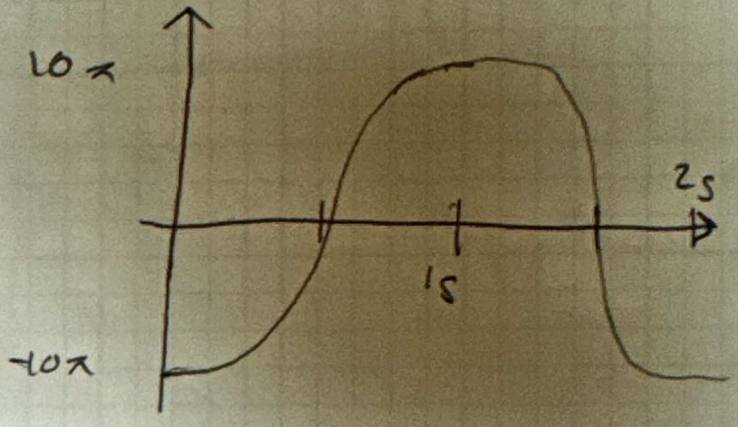
The equation for a differentiator is given by

$$V_{out} = -\tau \frac{dV_{in}}{dt}$$

for the sine wave

$V_{in} = 5\sin(\pi t) \rightarrow V_{out} = -10\pi\cos(\pi t)$

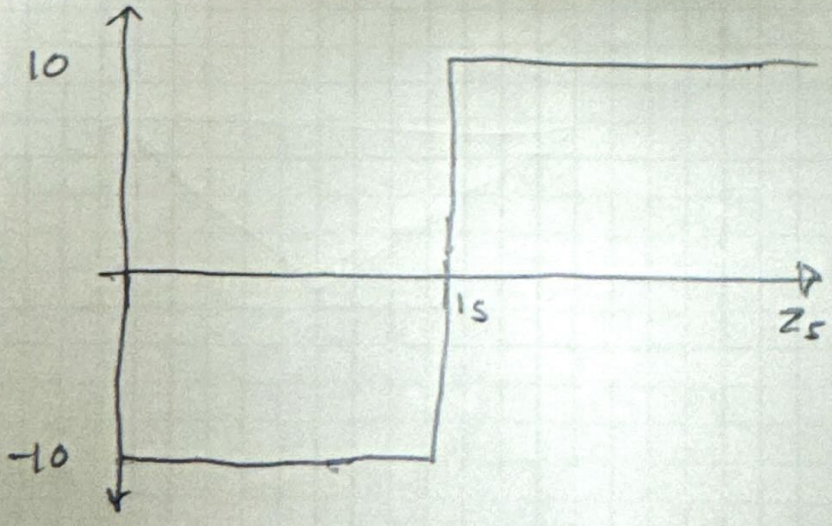
the graph for this is



For the triangle wave

$0 < t < 1 \quad V_{out} = -10$

$1 < t < 2 \quad V_{out} = 10$

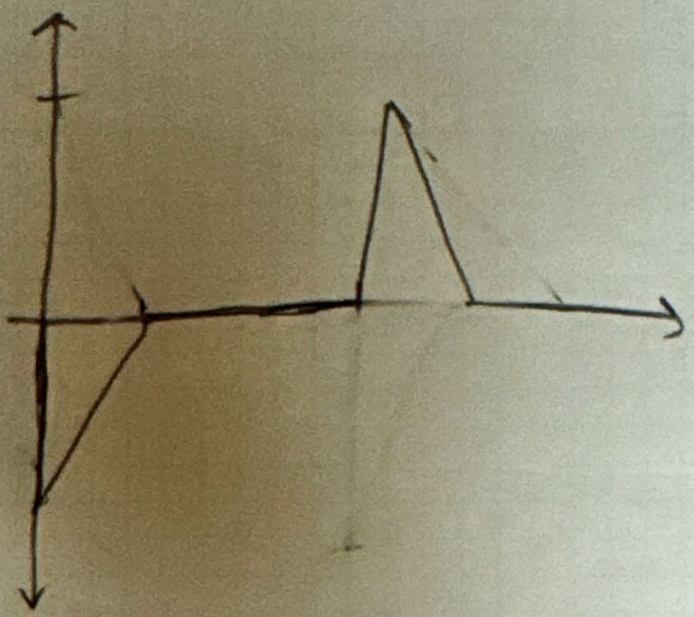


for the square wave (the problem one)

$V_{out} = 0$ volts mathematically, but

for the output voltage to be 0 the op amp would need to be shorted to ground.

Looking on the measured waveform looks like



The way that I can understand this is the voltage spikes to negative the square wave voltage and the capacitor bleeds the voltage back down to some median voltage.