

2001

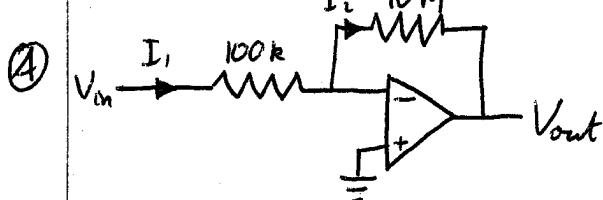
Paper 3

2001 (3)

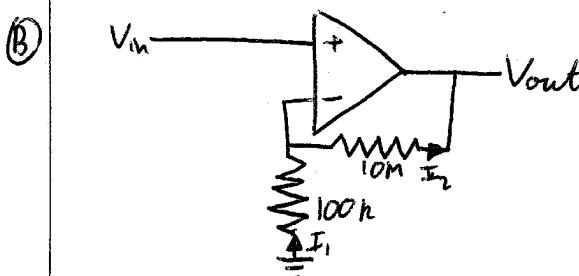
1. Voltage gain is the ratio of the output over input voltage in a circuit.

Input impedance is the effective resistance in series with the input for a device in an electrical circuit.

Output impedance is the effective resistance in series with the output for a device in an electrical circuit.



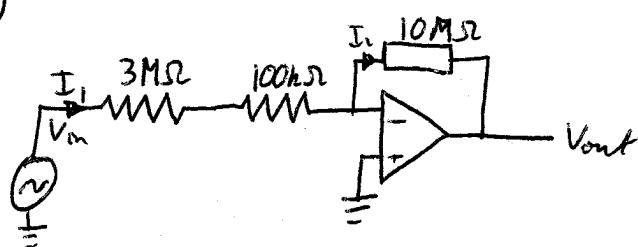
$$\begin{aligned}I_1 &= I_2 \\V_{in} - V_- &= 100k I_1 \\V_- - V_{out} &= 10M I_2 \\V_- \approx V_+ &= 0 \\ \Rightarrow \frac{V_{out}}{V_{in}} &= -\frac{10M}{100k} = -100\end{aligned}$$



$$\begin{aligned}I_1 &= I_2 \\0 - V_- &= 100k I_1 \\V_- - V_{out} &= 10M I_2 \\V_- \approx V_+ &= V_{in} \\ \Rightarrow V_{in} - V_{out} &= -\frac{10M}{100k} V_{in} \\ \frac{V_{out}}{V_{in}} &= 101\end{aligned}$$

Nerve has output impedance of $3M\Omega$

Connect to A

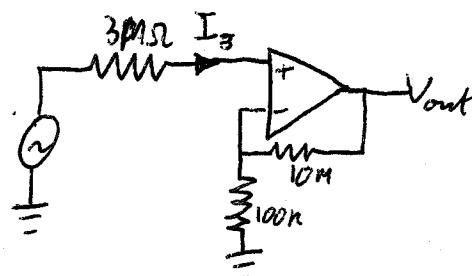


$$\begin{aligned}I_1 &= I_2 \\V_- \approx V_+ &= 0\end{aligned}$$

$$V_m = 3.1M I_1 ; -V_{out} = 10M I_1 \Rightarrow \frac{V_{out}}{V_m} = \frac{10}{3.1}$$

$$|V_{out}| \approx 3mV$$

Connect to ③; op-amp has ∞ input impedance $\Rightarrow I_3 \approx 0$



$$\therefore \frac{V_{out}}{V_{in}} = 101$$

$$|V_{out}| = 101 \text{ mV}$$

- Ⓐ has input impedance $100 \text{ k}\Omega$ which is small compared to the output impedance of the nerve. As a result the voltage gain is much smaller than the predicted -100
- Ⓑ has effectively ∞ input impedance, and so the output impedance of the nerve is irrelevant, and the circuit gives the predicted voltage gain of -99.