Which op-amp config, (inverting or noninverting), has highest input resistance. Use that config to design amp with $V_{gain} = 1000$.

Inverting: $V_{s}$ → $V_{o}$

1) $V_{i} = V_{f} = 0$V

Input resistance $R_{in} = \frac{V_{s}}{i_{s}}$

Gain circuit $V_{s}$ → $V_{o}$ since $i_{s} = V_{s} - 0V = V_{s}$

Clearly $v_{i} = R_{s}$ since $i_{s} = \frac{V_{s}}{R_{s}}$

Gain $= \frac{V_{o}}{V_{s}}$ in = 0 so $i_{f} = -i_{s}$

Feedback current flows in series resistor $R_{s}$.

$V_{o} = i_{f} R_{f}$ since $V_{i} = 0$ (from $V_{o} = V_{i} + i_{f} R_{s}$)

$= -i_{s} R_{f}$ since $i_{s} = 0$

$= -\frac{V_{s}}{R_{s}} R_{f}$ from above

Gain $= \frac{V_{o}}{V_{s}} = -\frac{R_{f}}{R_{s}}$

Non-inverting:

Input resistance $= \frac{V_{s}}{i_{s}} = \frac{V_{s}}{i_{f}} = \frac{V_{s}}{0}$

This has the higher input resistance.

Gain $= \frac{V_{o}}{V_{s}}$ Use ideal op-amp rules to find gain.

1) $V_{i} = V_{f}$ and $V_{f} = V_{s} \Rightarrow V_{i} = V_{s}$
ex: (cont. 2)  \( i_n = i_p = 0A \quad \Rightarrow \quad i_F \) flows thru \( R_S \) and \( R_F \)

\[
\frac{i_F}{R_S} = \frac{V_n - 0V}{R_S} = \frac{V_P - 0V}{R_S} = \frac{V_S - 0}{R_S} = \frac{V_S}{R_S}
\]

\[
V_o = V_n + i_F R_S = V_n + \frac{V_S}{R_S} R_S = V_P + \frac{V_S}{R_S} R_S = \frac{V_S + V_S R_S}{R_S}
\]

\[
\therefore \quad V_o = V_S \left(1 + \frac{R_F}{R_S}\right)
\]

Gain = \( \frac{V_o}{V_S} = 1 + \frac{R_F}{R_S} \)

We want gain = 1000. Use \( R_F = 999/R_S \)

Engineering considerations:

1) \( R_S \) we use are 10% so we just use \( R_F = 1000/R_S \)

2) Current if comes from \( V_o \) terminal of op-amp.

Op-amp such as LF353 that we use in lab is rated for max output current of 10 mA.

This means we must choose \( R_S \) and \( R_F \) such that

\[
\frac{i_F}{10mA} \leq \frac{V_n}{R_S} \quad \Rightarrow \quad \frac{i_S}{Rs} = \frac{V_n}{R_S} \quad \text{and} \quad i_F = \frac{V_o - V_n}{R_S} = \frac{V_o - V_S}{R_F}
\]

Given our gain is 1000 and \( V_o \) cannot exceed op-amp

pwr supply voltages, we conclude that \( |V_o| \leq 12V \)

(if our supply \( V_S \)s are \( V_{CC} = 12V \) \(-V_{CC} = -12V\).

Then \( \frac{|V_o|}{1000} = 12mA \)

So we need \( 12mA \leq 10mA \) or \( R_S \geq \frac{12mA}{10mA} = 12 \Omega \)

Just to be safe we can use \( R_F + R_S \geq 12k \Omega \) so that

if \( V_o = 12V \) and \( V_n = 1V \), (because \( V_S \) is too large and we no longer have linearity), we still have \( i_F \leq 1mA \). Use \( R_S = 130 \Omega \), \( R_F = 13k \Omega \).

Note: \( R_F < 1k \Omega \) also recommended so feedback not too weak. Double these for margin.